An Electrophysiological Examination of Intentional and Inadvertent Sleep Onset:

The Effect of Intention on the Sleep Onset Process

by

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A thesis
submitted in partial fulfilment
of the requirements for the degree
Master of Arts

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BROCK UNIVERSITY
St. Catharines, Ontario

August 1995

Acknowledgements

First, I wish to acknowledge my supervisor, Bob Ogilvie. He is a rare combination of excellent teacher, well respected researcher and genuinely kind and warm person. He has always encouraged me to think on my own and explore the area I was interested in. Bob has also taught me more than he realizes about life and he is an excellent role model to show that an academic need not be consumed by his/her work to be successful. He encouraged and motivated me to work hard and to be successful, but he has never lost the ability to see beyond the academic aspect of peoples' lives and reminded me that we are people first and academics second.

I also wish to extend my heartfelt thanks to my committee members Jane Dywan and Sid Segalowitz. They have also contributed greatly to my development over the years as well as providing invaluable feedback and advice concerning this thesis. I feel exceptionally fortunate to have had the opportunity to get to know as well as learn from these people. A student could not have asked for a better committee.

I could not have completed this work were it not for the help of Christi Alloway, Carole Lamarche, Tara Shaw and Sheri Allen. They helped apply electrodes, test participants and provided company to help me stay awake during testing.

Finally, I wish to acknowledge the help of my wife Wendy and my father Charles. She listened to my ideas, provided criticism when needed, chauffeured me safely home after those long nights, endured my tantrums during analysis, and spent countless hours proof reading and correcting this document. He provided the financial and emotional support all students should be fortunate enough to have. In short, this would have been a much more difficult task without their help.

Thank you all !!!!

Dedication

To Wendy,

my wife and best friend.

Abstract

The main purpose of this study was to examine the effect of intention on the sleep onset process from an electrophysiological point of view. To test this, two nap conditions, the Multiple Sleep Latency Test (MSLT) and the Repeated Test of Sustained Wakefulness (RTSW) were used to compare intentional and inadvertent sleep onset. Sixteen female participants (aged 19-25) spent two non-consecutive nights in the sleep lab; however, due to physical and technical difficulties only 8 participants produced compete sets of data for analysis. Each night participants were given six nap opportunities. For three of these naps they were instructed to fall asleep (MSLT), for the remaining three naps they were to attempt to remain awake (RTSW). These two types of nap opportunities represented the conditions of intentional (MSLT) and inadvertent (RTSW) sleep onset.

Several other sleepiness, performance, arousal and questionnaire measures were obtained to evaluate and/or control for demand characteristics, subjective effort and mental activity during the nap tests. The nap opportunities were scored using a new 9 stage scoring system developed by Hori et al. (1994). Power spectral analyses (FFT) were also performed on the sleep onset data provided by the two nap conditions.

Longer sleep onset latencies (approximately 1.25 minutes) were observed in the RTSW than the MSLT. A higher incidence of structured mental activity was reported in the RTSW and may have been reflected in higher Beta power during the RTSW. The decent into sleep was more ragged in the RTSW as evidenced by an increased number shifts towards higher arousal as measured using the Hori 9 stage sleep scoring method.

The sleep onset process also appears to be altered by the intention to remain awake, at least until the point of initial Stage 2 sleep (i.e. the first appearance of spindle activity). When only examining the final 4.3 minutes of the sleep onset process (ending with spindle activity), there were significant interactions between the type of nap and the time until sleep onset for Theta, Alpha and Beta power. That is to say, the pattern of spectral power measurements in these bands differed across time as a function of the type of nap. The effect of intention however, was quite small ($\eta^2 < .04$) when compared to the variance which could be accounted for by the passage of time ($\eta^2 = .10$ to $.59$).

These data indicate that intention alone cannot greatly extend voluntary wakefulness if a person is sleepy. This has serious implications for people who may be required to perform dangerous tasks while sleepy, particularly for people who are in a situation that does not allow them the opportunity to engage in behavioural strategies in order to maintain their arousal.

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Although the history of scientific sleep research (e.g., Patrick & Gilbert, 1896) is almost as old as the science of psychology (e.g., founding of Wundt's laboratory in 1879; books by Ladd, 1887 and James, 1890); interest in sleep research has not been as great as in other areas of psychology. This lack of interest may have been due, in part, to the inability to study this state without interrupting it. The development of the electroencephalograph (EEG) (Berger, 1929, as cited in Anch, Browman, Mitler, & Walsh, 1988) gave scientists the ability to study the sleeping brain. This technology made it possible to identify and classify various EEG patterns which were associated with various levels of sleep (Loomis, Harvey, & Hobart, 1937) including the onset of sleep (Davis, Davis, Loomis, Harvey, & Hobart, 1937, 1938).

Although the standard manual currently used for sleep stage scoring (Rechtschaffen & Kales, 1968) gives a relatively precise definition of when sleep begins based on EEG criteria (stage 1 sleep), the criteria are to some extent arbitrary. In fact, different definitions of what sleep is and therefore when a person is asleep will yield different sleep onset points. For example, if the inability to respond to external stimuli is employed as a definition of sleep, then the stage 1 criteria of Rechtschaffen and Kales (1968) cannot be considered to be unequivocal sleep since participants can respond to faint tones up to 40% of the time during this stage (Ogilvie & Wilkinson, 1984, 1988; Ogilvie, Wilkinson, & Allison, 1989).

An analogy can be drawn between the processes of maturation and falling asleep. It makes no more sense to speak of an adolescent one day before his/her eighteenth birthday as a child and the following day as an adult than it does to determine that at one

moment a person is awake and the next moment he/she is asleep. Each is a transitional process. Just as a human will at various times during his/her adolescence exhibit signs of maturity beyond his/her years or childishness belying his/her age, a person falling asleep will show various signs of both wakefulness and sleep before an unequivocal state of sleep is achieved.

The inherent difficulties encountered while attempting to determine a sleep onset point has led some sleep researchers to think of the transition from wakefulness to sleep in terms of a sleep onset period (e.g., Ogilvie & Wilkinson, 1988). This period includes some or all of the following stages: relaxed wakefulness, stage 1 and early stage 2 sleep. This transitional sleep onset period is now recognized by many researchers (see Ogilvie & Harsh, 1994). However, because like many transitional states it is difficult to study; it has often been ignored or controlled for rather than closely studied (see Pivik, 1991).

Sleep researchers are now in a much better position to more closely study the sleep onset period physiologically due to improvements in computer technology. The sleep onset period has recently been examined using multiple EEG sites (Hasan & Broughton, 1994), single hertz analysis (Badia, Wright, & Wauquier, 1994), and one second epochs (Armitage, Hudson, Fitch, & Pechacel, 1994). Virtually the only limitation on the thoroughness of the research has become the patience of the investigator since each breakdown of a parameter is accompanied by a proportional increase in the time required for the analysis.

Although examination of the sleep onset period is now much more common than in the past (see Ogilvie & Harsh, 1994), a review of the literature revealed that there has

been no work considering possible electrophysiological differences as a function of the intention of the person being studied. That is to say, **Is the process of falling asleep when one intends to remain awake (inadvertent) different from that when the person wishes to fall asleep (intentional)?**

For the purposes of this study inadvertent sleep onset was considered to be a sleep onset that occurred <u>despite</u> the intention to remain awake, not simply coming about by chance and/or without resistance. That is to say, inadvertent sleep is sleep which occurs despite an <u>active</u> attempt to remain awake. Intentional sleep onset was considered to be a sleep onset that was undertaken purposefully with no effort to remain awake being present. This would represent the typical conditions under which normal nocturnal sleep would occur.

Inadvertent sleep onset has been recognized as a major problem for many years (e.g., see Kleitman, 1963 p.316 for a review), and continues to receive much research attention (e.g., Akerstedt & Folkard, 1994). However, these types of studies have focused on behavioural, observational or subjective measures. It is to some extent surprising that a careful examination of inadvertent sleep onset from an electrophysiological point of view has not been undertaken earlier because the information needed for such an analysis has (in many cases) already been gathered as part of existing experiments and needed only to be examined. The current investigation sought to rectify this situation.

This paper will begin with a short review of pertinent sleep onset literature, followed by an outline of some standard measures used to determine the level of

sleepiness. The strengths and weaknesses of these measures with respect to the differential prediction of inadvertent versus intentional sleep onset will be discussed. The introduction will end with an outline of the present study.

Sleep Onset Period

The notion of a sleep onset period is not a new concept. In some of the first studies of sleep onset which incorporated EEG, Davis et al. (1937, 1938) discussed how a specific sleep onset point was impossible to determine. Davis et al. (1937, 1938) found that the "point" of sleep onset varied depending on the measurement used (EEG versus behavioural) and across subjects. These discrepancies among different indices of sleep are still being demonstrated in more recent work (e.g., Ogilvie, et al., 1989). Kleitman (1963), in his then encyclopedic textbook on sleep research, also indicated that determining a specific sleep onset point is problematic. More recently there has been a renewed interest in the sleep onset period (e.g., Ogilvie & Harsh, 1994).

Because sleep is such an important part of our existence, it is essential that we understand how this state is intentionally achieved. Alternatively, because the avoidance of sleep onset in specific circumstances (e.g., while driving a car) is critical for survival, furthering our understanding of unintentional or inadvertent sleep onset is equally important.

There has been a large amount of research done on intentional sleep onset. It has been studied subjectively, objectively, behaviourally, and physiologically (see Ogilvie, et al., 1989 for a specific example or Rechtschaffen, 1994 for a review). Problematic sleep onset has also been studied in terms of disorders such as insomnia

(Lamarche & Ogilvie, 1995), and narcolepsy (Valley & Broughton, 1995). The inability to intentionally initiate (e.g., insomnia) or avoid sleep (e.g., narcolepsy) can seriously diminish the quality of life for those who suffer from these types of disorders (Wagner, Ehrenberg, Bungay, & Rodgers, 1995).

Inadvertent sleep onset has most often been studied as it relates to vehicle operation (e.g., Pack, Cucchiara, Schwab, Rodgman, & Pack, 1994) or industrial accidents (see Akerstedt, 1991 for review). Akerstedt, using continuous ambulatory EEG monitoring in a variety of settings, has shown that inadvertent sleep onset at work is not an uncommon occurrence among shift workers (see Folkard & Akerstedt, 1991).

Sleep related accidents are very costly in terms of lives and dollars. Leger (1994) estimates that in the United States, between 43 and 56 billion dollars were lost in 1988 as a result of sleep related accidents of all types (vehicular, industrial, home). Leger (1994) points out that the actual number of accidents which can be directly linked to inadvertent sleep onset is difficult to assess. However, 41.6% of vehicular accidents (769,184 serious injuries) and 36.1% of fatalities (17,689 deaths) occurred during the times when sleepiness would be at its highest level due to circadian and environmental factors (Leger, 1994). Leger (1994) also produces similar statistics for work related accidents (5,565 deaths, 945,000 disabling accidents), and home related accidents (2,346 deaths, 408,762 disabling accidents).

These figures have been criticized (Webb, 1995) because they are based on numbers of accidents occurring during known times of increased sleepiness NOT actual data where the accidents were shown to be sleep related. Webb cites more conservative

estimates of sleep related accidents (under 2%). However, many States do not have consistent or reliable methods for investigators to indicate sleepiness or inadvertent sleep onset as the cause of an accident (Pack, Willis, & Pack, 1995) so the official estimates like those quoted by Webb (1995) are undoubtedly too low (McCartt, Pack, Walsleben, Hammer, & Pack, 1995).

The true values undoubtedly lie somewhere between Leger's (1994) and Webb's (1995) estimates, but the problem of inadvertent sleep onset in potentially dangerous situations is obvious. A better understanding of the differences between the processes involved in inadvertent and intentional sleep onset may someday help researchers identify people who are dangerously sleepy or the point at which the natural process of sleep onset overpowers any intent to remain awake.

Many researchers have attempted (with good success) to predict the probability of sleep onset in various situations (Webb, 1994; Akerstedt & Folkard, 1994). Akerstedt and Folkard (1994) and Webb (1994) have developed three process models based on the two factor Borbely-Daan model (Daan, Beersma, & Borbely, 1984). The initial two factor model (Daan et al., 1984) used the circadian tendency (process C) and sleep demand (process S) to estimate sleepiness or sleep tendency.

Akerstedt and Folkard (1994) added the influence of sleep inertia (the time required to attain full arousal after awakening) as their third factor. Using this model they can account for 88% of the variance in sleep onset latencies. Although 88% is a very large amount of variance to be able to predict, these types of studies are based on 24 hour periods. Despite the amount of variance which can be accounted for by these models in

predicting sleep onset latency, they are still inadequate when attempting to predict sleep onset on a moment to moment basis.

The third factor used in Webb's model (1994) deals with behavioural facilitation or inhibition. The behavioural component in this model consists of such variables as body position, current activity, noise, **intention**, etc. He points out, however, that these behavioural factors cannot easily be quantified and added to the equation containing the sleep demand and circadian variables. Each behavioural situation would have to be evaluated in context for its influence on the sleep onset latency to be measured.

None of the studies of intentional and/or unintentional sleep onset reviewed prior to the present study have compared these two variations of the sleep onset process moment by moment on a physiological level as sleep is either entered into normally or is being resisted.

Measurements of Sleepiness

Several methods have been developed to measure sleepiness or arousal, all of which can be divided into two basic categories, subjective or objective. Subjective measures rely on individuals' evaluations of their own state and include the Stanford Sleepiness Scale (SSS) (Hoddes, Zarcone, Smythe, Philips, & Dement, 1973) and the Visual Analogue Sleepiness Scale (VASS) (Folstein & Luria, 1973).

The SSS requires the participant to identify which of seven statements arranged in Likert-fashion best describes how he/she feels. These statements range from "alert, wide awake" (1) to "almost asleep" (7). The VASS requires the participant to indicate how tired he/she feels by drawing a mark on a 10 cm line which has "VERY ALERT" on the

left and "VERY TIRED" on the right.

Objective measures do not require any evaluation by the participant. These types of tests have the virtue of being uncontaminated by potential biases, misperceptions or inaccuracies which the participant may bring to the experiment. Unfortunately, they are still affected by biases, misperceptions and inaccuracies the experimenter may have.

The Multiple Sleep Latency Test (MSLT) is one commonly used objective measure of sleepiness. It is administered by placing electrodes (standard configuration) on a participant and having him/her lie in bed in a dark room and attempt to fall asleep. The score received on an MSLT is normally defined as the latency (in minutes) from lights out to the first of three consecutive 30 second epochs of stage 1 sleep or one epoch of any other sleep stage according to the sleep scoring system of Rechtschaffen and Kales (1968). At this point the participant is awakened and the test is repeated 4 to 6 times throughout the day at two hour intervals (see Richardson, Carskadon, Flagg, Van den Hoed, Dement, & Mitler, 1978 for complete instructions).

The original intended use of the MSLT was to identify individuals who suffer from some form of sleep disorder by objectively quantifying their degree of sleepiness during the day (Carskadon & Dement, 1982). Using the MSLT as part of a clinical evaluation remains one of its primary uses (Thorpy, 1992). While the MSLT has proven useful as a clinical tool (Thorpy, 1992), the careful examination of the electrophysiological microstructure of the naps has not been carried out despite the power spectral data being available or easily obtainable in many cases. Thus, a great deal of information regarding both normal and pathological sleep onset has been ignored.

One of the problems with the MSLT is that although it was intended as a measure of sleepiness, it is also partially a measure of one's ability to fall asleep rather than purely one's physiological sleep tendency (Naitoh & Kelly, 1994). It was not designed to measures one's ability to stay awake while sleepy. This distinction becomes quite important if the researcher is attempting to evaluate a participant's ability to perform a task while sleepy or maintain wakefulness despite increasing sleep pressure.

Several alternative methods of measuring a participant's ability to resist sleep have been proposed to correct this problem. Among them are the Maintenance of Wakefulness Test (MWT) (Mitler, Gujavarty & Browman, 1982) which has the participant seated and told to stay awake, the Modified Maintenance of Wakefulness Test (MMWT) (Timms, Shaforenko, Hajdukovic, & Mitler, 1985) which differs from the MWT only in duration, the Modified Assessment of Sleepiness Test (MAST) (Erman, Beckman, Gardner, & Roffwarg, 1987) which has participants seated and reading while trying to remain awake.

These alternate paradigms each have several differences from the original MSLT (body position, lighting, length of test, instructions, etc.) and they produce different results. For example, the MWT has been found to manifest sleep latencies three times longer than those observed in the MSLT (Mitler et al., 1982). This difference may be due, in part, to the instructions to stay awake. However, the MWT also has participants seated, and there is no specific instruction concerning eye closure. In order to accurately determine the effect of instruction alone, the Repeated Test of Sustained Wakefulness (RTSW) (Hartse, Roth, & Zorick, 1982) was developed. It is identical to the MSLT (dark room, eyes closed, participant in supine position) with two exceptions. The

maximum length of the test is 30 minutes and the instructions are "close your eyes, but try to remain awake".

Using this paradigm, longer sleep latencies were observed on average for the RTSW than the MSLT during daytime testing after a normal night of sleep (Hartse et al., 1982). However, there was no significant difference observed after one night of sleep loss. The question arises as to whether this indicates that intention alone could not significantly alter the sleep onset process; or perhaps the effort of the participants was insufficient to delay sleep onset.

Another possibility is that these processes do differ in an appreciable way but researchers have not been employing sufficiently sensitive tools to observe this difference. Perhaps an EEG measure more sensitive to the sleep onset process than the current Rechtschaffen and Kales (1968) criteria, or a careful microanalysis of the EEG changes may show these differences.

Other researchers have failed to find any significant increase in sleep onset latencies in the RTSW (Sugerman & Walsh, 1989). As mentioned above, potential reasons for the non-significant differences in the sleep latencies could include non-compliance by the participant (lack of intention) or insufficient effort. It has also been suggested that perhaps participants are exhibiting demand characteristics since the paradigm of the RTSW appears to be so contradictory. Participants are asked to lie in bed in a darkened room with their eyes closed and yet remain awake? Participants may also not exert maximum or consistent effort to remain awake across sessions or between tests.

This point leads to a major weakness of all nap tests (MSLT, RTSW, MWT,

MMWT etc.). There is no attempt to control for, or evaluate the participant's mental state during testing. Anxiety (Rose, Ware, Wooten, & Bond, 1995) can prolong sleep onset. Also, lack of effort or lack of arousal by the testing situation can skew results (Broughton, 1994; Naitoh & Kelly, 1994).

Therefore, any use of nap tests such as the MSLT, and especially the RTSW, should be used in conjunction with explicit instructions and some follow-up interview or questionnaire to evaluate the participant's effort and intentions during the test. This also allows for the investigation of demand characteristics.

Also, the analysis of the ongoing EEG activity should include more than simple measurement of the latencies. There is a vast amount of information regarding the sleep onset process that has been overlooked since the inception of nap tests. Akerstedt (1991), in a book chapter on shift work, describes several studies where continuous EEG (usually at least 24 hours) was obtained using portable Medilog recorders. Some of these records include both intentional and inadvertent sleep onsets. The inadvertent sleep onsets can be identified because they often occurred during work periods. The participants typically did not acknowledge the existence of these naps during follow-up interviews and claimed to be unaware they had slept. The focus of the present investigation was this information on inadvertent sleep onset which, to date, has been overlooked.

Sleepiness Measures used in the Present Study

For the present study the SSS and VASS were chosen as subjective measures of sleepiness because of their reliability and ease of administration. The objective measures were the MSLT and the RTSW. The MSLT was chosen because it is a well established

and validated test. The RTSW was chosen because of its similarities to the MSLT. This allowed further evaluation of the effect of instruction without the confounds of differences in body position or eye closure instructions.

It has been known for several decades that the closing of the eyes results in an increase in the amount of alpha in one's EEG (Davis et al., 1937). Therefore, because a spectral analysis was going to be performed, both the naps tests had to be conducted with the eyes closed. The MSLT and RTSW both satisfied this criterion.

The Alpha Attenuation Test: An Objective EEG Measure of Alertness

The Alpha Attenuation Test (AAT) is a recently developed test (Michimori, Araki, & Hagiwara, 1990, as cited in Michimori, Stone, Aguirre, & Stampi, 1994) although its primary uses or strengths are still under investigation. The AAT has been proposed as a good measure of sleepiness (Stampi, Stone, & Michimori, 1993), and alertness (Michimori, Stone, et al, 1994) because it correlates highly with the MSLT. It has also been shown to correlate well with performance measures (Michimori, Stampi, & Stone, 1993). Recently, the AAT has also been shown to be effective in assessing increased sleepiness in shift workers (Heitmann, Stampi, & Anandan, 1995) and narcoleptics (Alloway, Ogilvie, & Shapiro, 1995).

The paradigm for the AAT is similar to one used by Akerstedt and Gillberg (1990). Both involve having the participant open and close his/her eyes and comparing the power in the alpha band between the two conditions. The original AAT (Michimori et al. 1990, as cited in Michimori, Stone, et al. 1994) required the participant to alternately open and close his/her eyes every two minutes for a total of 12 minutes. Electroencephalographic

(EEG) recordings were taken from O1-A2 and frequency analyses (FFT) were done using 5 second epochs to calculate the mean power spectra for the alpha band for each eyes open (EO) or eyes closed (EC) segment. The alpha attenuation coefficient (AAC) was then calculated by determining the ratio of mean power during the eyes closed segments to the eyes open segments. The larger the AAC, the greater the alertness level. This would then represent a low tendency for sleep to occur or a long sleep onset latency.

Stampi, Michimori, and Aguirre (1995) have also shown that the AAT can be significantly reduced in length while maintaining its ability to predict sleepiness. The present investigation therefore used a shorter variation of the original AAT. The original two minute segments were reduced to 60 seconds.

Sleep Stage Scoring

With the exception of REM sleep, sleep has been categorized into basically the same discrete stages for almost 60 years (Loomis et al., 1937; Dement & Kleitman, 1957; Rechtschaffen & Kales, 1968). These various, but similar, scoring systems all express sleep as occurring in 4 or 5 stages. However, they all carry an implicit sleep onset point since early stages are typically expressed as relaxed wakefulness with the following stages labelled as sleep of one type (stage) or another.

As indicated earlier, sleep onset is not an instantaneous occurrence, it is a process. This fact has been recognized for some time (Davis et al., 1937; Kleitman, 1963; Ogilvie, & Wilkinson, 1988; Rechtschaffen, 1994). However, the standard scoring systems employ criteria which are too varied and epoch lengths which are too long to allow for a fine grained analysis of the sleep onset period. In fact, traditional sleep scoring

instructions (Rechtschaffen & Kales, 1968) advise individuals to ignore momentary EEG inconsistencies and score each 30 second epoch based on the overall characteristics of the epoch. This method reduces the clarity of the sleep onset process.

In determining when a person is awake, behavioural, observational, and physiological indicators are in essentially complete agreement (Ogilvie, & Wilkinson, 1988). Also, there is reasonably strong, although occasionally equivocal, evidence among the three types of measurements mentioned above that stage 2 (Rechtschaffen & Kales, 1968) represents unambiguous sleep. This means that the majority of the sleep onset process takes place during what has been defined as stage 1 sleep. During this stage, there are EEG indicators of sleep; however, there are inconsistencies when subjective or behavioural indices are used (Ogilvie, et al., 1989).

Some effort has been made in the past (Loomis et al. 1937) and again more recently (Valley & Broughton, 1983) to distinguish between early and late stage 1 sleep. This modification, while an improvement, is still too crude to allow for a detailed examination of the sleep onset process.

A New Scoring System for the Sleep Onset Period

In order to represent the sleep onset process more precisely, Hori, Hayashi and Morikawa (1994) developed a nine stage system for scoring the sleep onset period. These nine stages encompass the Rechtschaffen and Kales (1968) stages of relaxed wakefulness (Hori stages 1 and 2), stage 1 sleep (Hori stages 3-8), and initial stage 2 (Hori stage 9) and are scored in 5 second epochs. These stages have been validated by comparing them to reaction times, subjective assessments of sleep, and hypnagogic imagery.

By using Hori's nine stages, the sleep onset period can now be examined in much greater detail. The use of 5 second epochs allows for the recognition and quantification of rapidly occurring changes in EEG (and presumably the underlying changes in arousal they represent).

Power Spectral Analysis (FFT) of the Sleep Onset Period

There are several stable changes which occur during the sleep onset period. Several studies have found that root mean square power associated with the slower bands (e.g., Delta and Theta) increases while faster bands (e.g., Alpha, Beta) decrease as a person moves towards sleep (e.g., Badia et al., 1994; Hori, 1985). Ogilvie, Simons, Kuderian, MacDonald and Rustenberg (1991) further quantified these changes by grouping samples of EEG into 5 bins according to response time to a faint auditory tone. The first four bins represented increasing response times by quartile and the fifth represented a failed response (behavioural sleep onset). Ogilvie et al. (1991) found that there was a significant increase in power across all bands from bin 4 (slowest responses) to bin 5 (failed response). When comparing bins 1 through 4, there were no significant changes in Delta or Sigma, steady (although not always significant) increases in Theta, and uniform (although not significant) decreases in Alpha and Beta.

These data however, do not address the temporal aspect of sleep onset. The units compared were based on a behavioural measure of sleepiness (reaction time) and binned accordingly. The participants, however, did not pass through these bins in a linear, uniform manner. The response times were varied with several decreases as well as increases in response times when compared to previous trials. This speaks to the

variability of the sleep onset process. It is seldom a uniformly smooth transition from wakefulness to sleep.

Variability of the Sleep Onset Process

If sleep onset is not a uniform process then how is it to be studied in a temporal manner? It has been shown that power in the Delta and Theta bands increases *in general* as a person moves from wakefulness to sleep. Also, the power in the Alpha and Beta bands decreases *in general* during this same period (Badia et al., 1994). Perhaps the smoothness of this transition could be used as a means to distinguish between intentional and unintentional sleep onset. From this perspective, intentional sleep onset would be predicted to have a more consistent, and thus smoother trajectory, than unintentional sleep onset. How then can these trajectories be quantified?

The Concept of a Sleep Trajectory

If the passage one takes from clear wakefulness to unambiguous sleep is thought of as a mathematical function, then the functions which represent Delta and Theta should increase over time and hence should have an overall positive slope (in general). Similarly, the functions representing Alpha and Beta should have negative slopes because the power in these bands drops as sleep approaches. These functions could be thought of as a sleep trajectory and could be measured by examining the mean spectral power levels for each frequency as a function of time during the sleep onset period.

Slope Changes as a Measure of Sleep Trajectory

With the knowledge we have of the EEG changes during the sleep onset period it may be reasonable to assume that each decrease in Alpha or Beta power and/or increase in

Delta or Theta power should be indicative of a move towards lowered arousal or sleep. Concomitantly, each increase in Alpha or Beta and/or decrease in Delta or Theta power can be viewed as a move towards wakefulness.

An analysis of these slope changes would yield a measure of the smoothness of the wake/sleep transition. Hence, the trajectory from wakefulness to intentional sleep should yield fewer slope changes than would the similar process to unintentional sleep.

Slope Changes in Sleep Stage Scoring

A similar argument can be made for visually scored sleep stages. The original Rechtschaffen and Kales (1968) sleep scoring system would only have 3 components at most in the sleep onset process (wakefulness, stage 1 and initial stage 2). This system, with only 3 potential stages and 30 seconds epochs, would likely not be sensitive enough to show differences in the number of stage changes reliably. However, Hori's 9 stage system, using 5 second epochs, should provide the necessary resolution to see quantitative differences between the processes of intentional and unintentional sleep onset.

Objectives

This study was designed to closely examine and quantify the differences between intentional and inadvertent sleep onset from an electrophysiological point of view. It is these processes which were the focus of this study. It is fortunate that two nap tests exist which fit the necessary criteria precisely. The MLST and RTSW served as these two nap tests. Follow-up measurements were taken to evaluate the degree of compliance with instructions and effort during each type of test. Other measurements included two subjective sleepiness measures (SSS, VASS), as well as two objective measures of arousal

(AAT, oral temperature) and a performance measure (reaction time).

Hypotheses

Although Hartse et al. (1982) did not find significant differences in the sleep onset latencies between the RTSW and the MSLT when their participants had been deprived of sleep, the amount of sleep deprivation in this study is not as great as in their study. It is therefore hypothesized that sleep onset latencies will be longer during the RTSW than the MSLT.

Unintentional sleep onset should follow a more ragged trajectory because the descent into sleep will be periodically reversed by the intent to remain awake. Therefore, the second hypothesis is that there will be more slope changes per unit time in the RTSW for Delta, Theta, Alpha and Beta power, as well as Hori stage changes.

Because of the effort being expended during the RTSW. It is expected that the increases in Delta and Theta and decreases in Alpha and Beta observed during the sleep onset period will not take place until later in the process. This third hypothesis will be expressed statistically as an interaction in the power data for Delta, Alpha, Theta and Beta between the type of nap and time since lights out (beginning of the nap test).

There will also be a significant difference in the mental activity between the two tests. It is hypothesized that participants will spontaneously engage in more structured thoughts during the RTSW and more dreamlike or freeform mentation during the MSLT. This should produce higher Alpha and Beta power in the RTSW and higher Theta power in the MSLT.

Therefore, the four main hypotheses can be summarized as follows:

Hypothesis 1 - The sleep onset latencies in the RTSW will be longer compared to those in the MSLT.

Hypothesis 2 - There will a more ragged sleep trajectory in the RTSW which will be demonstrated by an increased number of slope changes in the power data and more Hori stage changes.

Hypothesis 3 - The typical changes during sleep onset will occur later in the RTSW.

Hypothesis 4 - There will be evidence of more structured thoughts in the RTSW.

Method

Participants

The participants were sixteen female students (aged 19-25). All were enrolled in an introductory psychology course. Participants received course credit as well as $25 for their participation. All participants were non-smokers, self-reported normal sleepers (6-8 hours per night), not currently taking any medications other than oral contraceptives, and had self-reported moderate use of alcohol and caffeine. All participants had midrange scores on the Horne-Ostberg (1976) morningness\eveningness scale and reported no history of head injury or other neurologic abnormalities.

Procedure

Participants were given a preliminary tour of the sleep lab one to two weeks prior to testing during which time all tests and measurements were explained and a consent form was signed (see Appendix A). At this time participants were also administered the Horne-Ostberg Morningness/Eveningness scale as well as a screening questionnaire to evaluate their typical sleep patterns (see Appendixes B and C). If the participant scored in the midrange of the Horne-Ostberg scale, had normal sleep patterns and agreed to participate, she was chosen for inclusion in the study. To reduce practice effects, participants were then administered the reaction time test, as well as the SSS and VASS (see Appendixes D and E).

Participants were required to complete sleep logs for one week prior to each night in the lab (see Appendix F). These sleep logs were designed to yield data on the sleep patterns of the participants several days prior to testing and also to allow them to become

familiar with the SSS and VASS.

Testing was done on two non-consecutive nights (usually one week apart). Scheduling was arranged to avoid menses. Participants were instructed to refrain from alcohol consumption for 24 hours before testing began, to sleep normally, awaken themselves by 7:00 a.m. and refrain from napping the day of the tests. They were to arrive at the sleep lab no later than 8:30 p.m. They were then given final instructions regarding the procedure, given a pre-sleep questionnaire (see Appendix G) to evaluate the length and quality of the previous night's sleep as well as their current frame of mind (level of anxiety, happiness, etc.) while the electrodes were being attached.

Electrodes to record EEG were placed at F4, C3, C4, P4, and O2 (10-20 system, Jasper, 1958). Horizontal eye movements (EOG) were monitored using two electrodes (left and right outer canthus). The above electrodes were referenced to linked mastoids and grounded to a second electrode on the right mastoid. Muscle activity (EMG) was monitored from two bipolar electrodes under the chin (submental muscles). The EEG electrodes were affixed using collodion soaked gauze pads; all other electrodes were affixed with surgical tape. All electrodes were made of silver, filled with electrode cream and interelectrode impedance was maintained below 5 Kohm.

Electrophysiological data were amplified using a 14-channel Nihon Kohden electroencephalograph (EEG). EEG recordings were digitized at 102.4 Hz, stored on a personal computer using a custom EEG acquisition and analysis program (MQE[1], Imaging

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[1] I wish to thank Imaging Research for the use of their MQE digital signal processing software.

Research) and stored in 10 second epochs. The EEG and EOG were amplified using a time constant of .3 seconds and a high cut filter of 35 Hz. The time constant and high cut filter settings for the EMG were .03 seconds and 75 Hz respectively. All EEG data (AAT, MSLT, RTSW) were collected with the participant in a sound-attenuated, electronically shielded bedroom which contained a single bed, dresser, closet, night table, lamp, video camera and intercom. Participants were informed that the intercom and video were operating for communication purposes only and that no permanent recording was being made.

The tests evaluated in the present paper included two types of nap opportunities, (MSLT and RTSW), two subjective measures of sleepiness (SSS and VASS), one electrophysiological measure of arousal (AAT), as well as oral temperature and reaction time. Testing began at 10:00 p.m. each night and was completed by approximately 3:40 a.m. (see table 1). Participants were monitored constantly during this time. No sugar or caffeine was consumed immediately prior to or during the study.

AAT Administration and Scoring

During the AAT, participants were seated in their bed and instructed to look at a target (50 mm by 50 mm black square) mounted on the wall at eye level approximately 4 m from the participant. Participants were initially required to look at this target with their eyes open (EO). After 6 artifact free epochs (1 minute) they were then instructed to close their eyes (EC) but to "try not to move your eyes" for another 6 artifact free epochs (see Appendix H for full instructions). If there were artifacts observed in the EEG, then additional epochs were added to assure a minimum of 60 seconds of data from each

segment of the AAT. This procedure was repeated two more times for a total of three EO and three EC segments.

The alpha attenuation coefficient (AAC) was determined by calculating the ratio of the mean EC power over mean EO power from the Alpha band (8-12 Hz). These data were obtained from the O2 electrode site. All AACs were calculated using a total of 18 artifact-free epochs for each EO and EC condition.

Table 1

This is format 1. For the second night exchange the MSLT and RTSW tests.
Format 2 is identical except the nap tests are exchanged.

Session	Time	Tests	Session	Time	Tests
1	21:45	SSS VASS temp	4	00:45	SSS VASS temp
	21:55	water, walk		00:55	water, walk
	22:00	AAT		1:00	AAT
	22:09	RT		1:09	RT
	22:14	SSS VASS temp		1:14	SSS VASS temp
	22:15	MSLT		1:15	RTSW
	22:40	Nap Test Ends		1:40	Nap Test Ends
2	22:45	SSS VASS temp	5	1:45	SSS VASS temp
	22:55	water, walk		1:55	water, walk
	23:00	AAT		2:00	AAT
	23:09	RT		2:09	RT
	23:14	SSS VASS temp		2:14	SSS VASS temp
	23:15	MSLT		2:15	RTSW
	23:40	Nap Test Ends		2:40	Nap Test Ends
3	23:45	SSS VASS temp	6	2:45	SSS VASS temp
	23:55	water, walk		2:55	water, walk
	24:00	AAT		3:00	AAT
	00:09	RT		3:09	RT
	00:14	SSS VASS temp		3:14	SSS VASS temp
	00:15	MSLT		3:15	RTSW
	00:40	Nap Test Ends		3:40	Testing Ends

SSS - Stanford Sleepiness Scale
VASS - Visual Analogue Sleepiness Scale
AAT - Alpha Attenuation Test
MSLT - Multiple Sleep Latency Test
RT - Reaction Time Test
RTSW - Repeated Test of Sustained Wakefulness
temp - Oral Temperature
water,walk - Small glass of water and a 50 m walk

Note:Due to various physical and technical problems this schedule was altered as required during testing. However, the length of each test remained constant.

Nap Tests

The order of nap tests was counterbalanced across participants and nights (see table 1). For both types of nap tests, participants were dressed in their usual night clothing. They were then asked to lay down in a single bed in a private bedroom. After the instructions had been read, the main lights were turned out, the door closed and recording began (the red 40w light necessary for video monitoring was left on). For the MSLT the complete instructions to the participants were

> "For this test you are to close your eyes, lay still, relax and allow yourself to fall asleep. Any questions? Good Night".

The instructions for the RTSW were as follows,

> "For this test you are to close your eyes, lay still and relax, but do your best to remain awake. These instructions may seem very contradictory but I am not trying to mislead you in any way. For the purposes of my study it is important you follow them as closely as you can. It is important that you close your eyes, but remain awake as long as possible. It is also important that you do not unnecessarily move, or engage in any mental activity such as singing to yourself. Movements, even the tiny ones which occur when you sing to yourself, or tap your feet will be picked up by the EEG machine and make your data harder to interpret. Of course if you are uncomfortable feel free to reposition yourself as you would normally. Any Questions? Remember, close your eyes but try and stay awake."

MSLT and RTSW testing was terminated 25 minutes after lights out. This time limit was observed regardless of whether the participants fell asleep in that time.

Subjective Sleepiness Measures

The SSS (Hoddes et al., 1973) is a seven point scale used to measure subjective sleepiness. The participant is asked to pick one statement which best describes how he/she feels. These statements range from (1) "alert, wide awake", to (7) "almost in

reverie, sleep onset soon, lost struggle to remain awake" (see Appendix D). The VASS consists of a horizontal line 10 cm in length with "VERY ALERT" to the left of the line and "VERY SLEEPY" to the right of the line (see Appendix E). Participants placed a mark on the line to indicate where on this continuum they judged themselves to be. The score on the VASS was the distance from the left end point of the line, thus higher scores were associated with increased sleepiness.

The SSS and VASS were administered and oral temperature was taken every 30 minutes (at quarter to and quarter past the hour). However, only those measures taken at quarter past the hour were analyzed. These measures occurred immediately prior to a nap opportunity.

Reaction Time Measure (RT)

Reaction time measurements were taken with the participant seated on the side of her bed. A personal computer on a portable cart was placed at the bedside of the participant. Participants were instructed to press the space bar with their dominant hand as soon as they observed a square in the middle of the screen[2]. The stimuli appeared every 3 to 5 seconds with an average inter-stimulus interval of 4 seconds. There were a total of 60 stimuli. Once the test was completed the computer was turned off and taken away from the bed. Anticipatory responses were excluded from the analysis.

Order of Tests

The tests were administered in the following fashion. The participants were tested in six, one hour blocks. Each block began 15 minutes prior to the hour and contained, in

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[2] I wish to thank Sid Segalowitz for the use of his custom reaction time program.

order, the SSS, VASS and oral temperature, followed by a short walk (50-100 metres) and small drink of water. Beginning on the hour, each participant was then given the AAT, RT, SSS, VASS, oral temperature, and finally a nap test (MSLT or RTSW). The nap tests typically began at 15 minutes past the hour and were terminated 25 minutes later. The two types of nap tests were counterbalanced across sessions, participants, and days. Each participant underwent 6 naps (3 of each type) each night for a total of 12 naps. However, only the final 4 naps for each night were scored. This was made necessary because several participants did not fall asleep during the earliest nap opportunities.

Post-Experiment Debriefing

Following their second night in the lab, participants were given a post-experiment questionnaire (see Appendix I). This questionnaire evaluated each participant's level of effort, subjective rating of performance, use of strategies, and thought patterns in each test. Another very important part of this questionnaire asked how convinced the participant was concerning the real purpose of the experiment. This was done to help determine if there were excessive demand characteristics based on incorrect assumptions.

Scoring of Sleep Onset Period

The sleep onset period for each participant was visually scored on a computer monitor (using MQE) in 5 second epochs. Epochs with artifacts due to movement or electrical interference were discarded. These 5 second epochs were scored using a nine stage system developed by Hori (Hori et al., 1994). This system breaks down the original Rechtschaffen and Kales (1968) stages of relaxed wakefulness, stage 1 and initial stage 2 into 9 discrete stages.

The nine Hori stages are defined as follows: (from Hori et al, 1994 p. 240)

Stage 1: Alpha wave train: Epoch composed of a train of alpha activity with a minimum amplitude of 20 μV.

Stage 2: Alpha wave intermittent (A): Epoch composed of a train of more than 50% alpha activity with a minimum amplitude of 20 μV.

Stage 3: Alpha intermittent (B): Epoch contained less than 50% of alpha activity with an amplitude of 20 μV.

Stage 4: EEG flattening: Epoch composed of suppressed waves of less than 20 μV.

Stage 5: Ripples: Epoch composed of low-voltage theta waves (20-50 μV).

Stage 6: Vertex sharp wave solitary: Epoch contained one well defined vertex sharp wave.

Stage 7: Vertex sharp wave trains or bursts: Epoch contained at least two well defined vertex sharp waves.

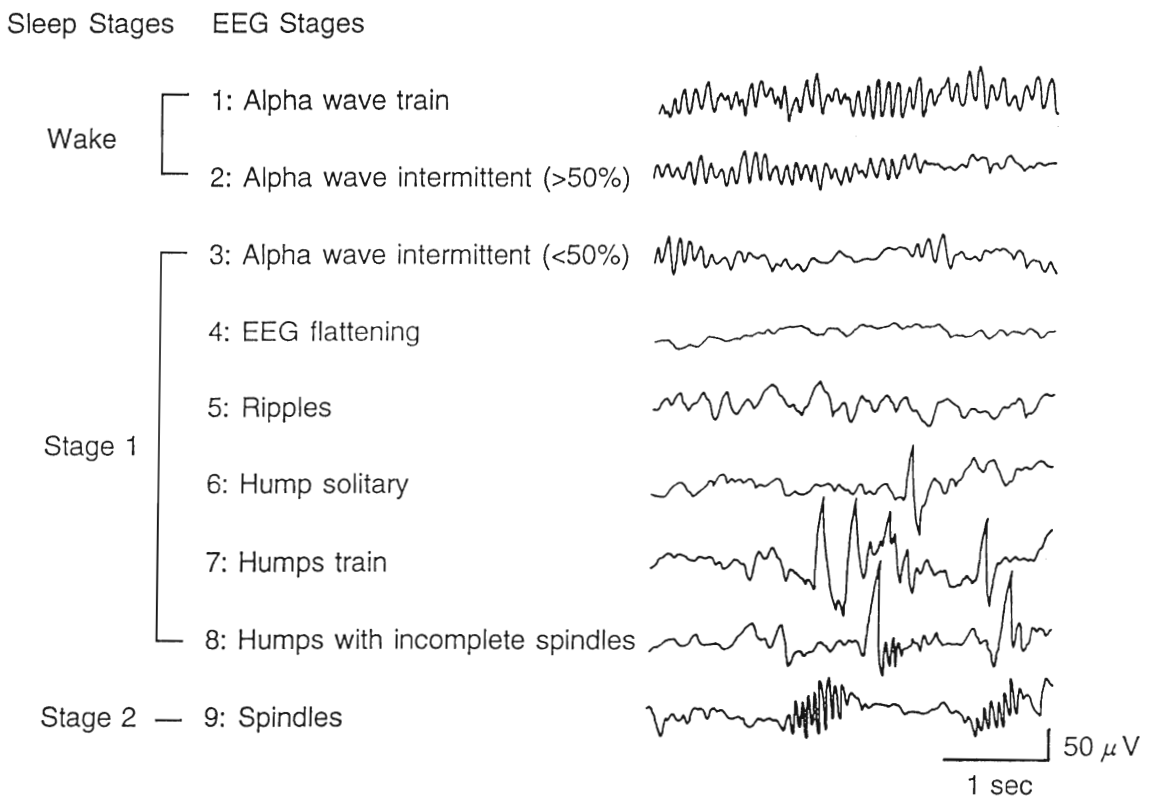
Stage 8: Vertex sharp wave and incomplete spindles: Epoch contained at least one well defined vertex sharp waves and one incomplete spindle: duration < .5 s, amplitude < 20 μV).

Stage 9: Spindles: Epoch contained at least one well defined spindle at least .5 s in duration and 20 μV in amplitude.

(see figure 1 for examples)

Figure 1

Example of Hori Stages



Stages 1 and 2 in the Hori system correspond to relaxed wakefulness in the Rechtschaffen and Kales (1968) system. Stages 3 through 8 would fall into stage 1 of the Rechtschaffen and Kales (1968) system. Stage 9 in the Hori scale corresponds to early stage 2 in Rechtschaffen and Kales (1968) criteria.

These stages were scored in context when necessary. If an epoch was ambiguous in nature, but did not display characteristics inconsistent with the scoring of the previous epoch, it was scored the same stage as that previous epoch. Thus, stage changes reflected unambiguous changes in the composition of the EEG record.

There were two minor modifications to the original criteria as outlined by Hori (Hori, et al 1994). First, in the event that an incomplete spindle was observed in the absence of a vertex sharp wave, the epoch was scored at stage 8. Second, because the presence of a K-complex is considered to be a sign of stage 2 sleep by Rechtschaffen and Kales (1968) criteria, if a K-complex was observed, the epoch was scored as stage 9.

The sleep onset period was defined as the time from lights out to the first occurrence of 6 consecutive epochs (30 seconds) of predominantly stage 9 sleep. Predominantly stage 9 sleep was defined as at least 4 of 6 consecutive epochs scored as stage 9, including both the first and last epoch scored as stage 9.

Power Data

Each artifact-free 5 second epoch also underwent an FFT analysis to determine the absolute power for each of the standard bandwidths (Delta, .5-4 Hz, Theta 4-8 Hz, Alpha, 8-12 Hz, Sigma 12-15 Hz and Beta 15-25 Hz).

Analysis of Slope Changes

Temporal changes in EEG power and Hori sleep stages were analyzed using a custom DOS-based program (Arouse[3]) which detects slope changes within a number series. There are two important features of the Arouse program. First, because there can be a large amount of variation in the length of sleep onset records, Arouse allows the user to divide the record into equally sized units (halves, thirds, quartiles, etc.) for a more appropriate comparison. Secondly, because the significance of small changes in EEG power are uninterpretable (Townsend & Johnson, 1979), Arouse allows the user to specify a minimum change necessary (jitter factor) for a true slope change to be reported. This jitter factor is expressed as a percentage of the standard deviation of the entire record (see figure 2 for an example).

For all power data analysis the jitter factor was set at 50% (1/2 of 1 standard deviation). This was chosen to eliminate smaller changes in slopes (the smallest 40%). For all Hori stage analysis, the jitter factor was set at 0% because every stage change was considered to be significant. Because a longer sleep onset latency would allow for potentially more slope changes due to the size of the record alone, slope change data was expressed as a ratio of the actual number of slope changes compared to the maximum number of possible slope changes (i.e., number of slope changes/(number of epochs - 1)).

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[3] I wish to thank Jennifer Ogilvie for her help in programming Arouse.

Example of Slope Changes *Arouse* would Detect

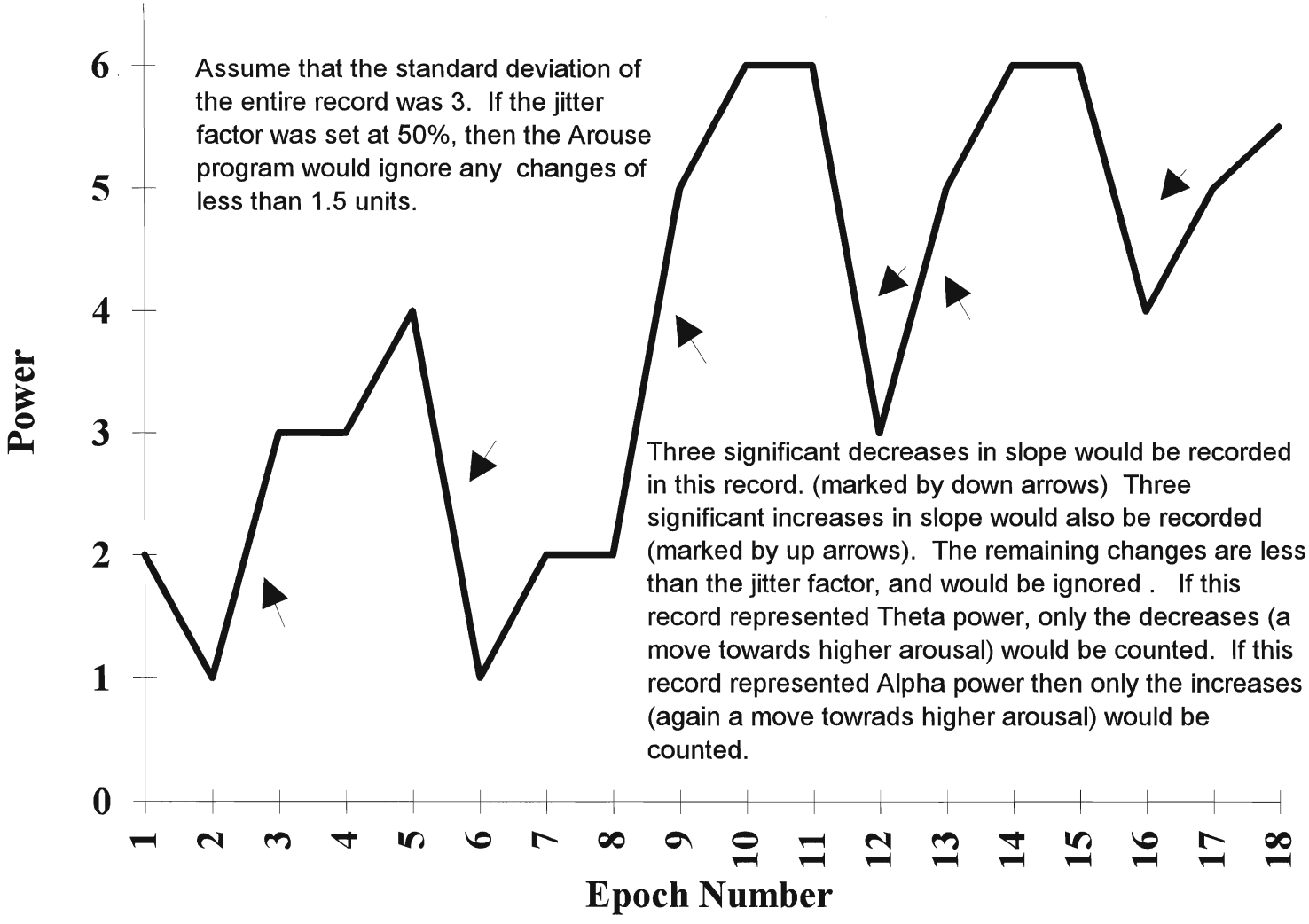


Figure 2

Results

Design and Statistical Considerations

Of the original 16 participants, only 8 had complete sets of data for a full analysis. Four participants did not fall asleep during at least one of the nap tests, one participant had excessive electrical interference on her EEG, 2 participants had sleep onset REM periods (SOREMP), and one had a cold the second night of testing. Unless explicitly stated all analyses reported involve only the 8 participants for whom complete sleep onset data were obtained.

All records (naps) were initially divided into equal quartiles which will be referred to as Divisions. The main comparison of interest was between the MSLT and the RTSW. This factor will be referred to as Nap Type (MLST versus RTSW). For some analyses, the early naps (12:00 and 1:00 a.m.) will be compared to the late (2:00 and 3:00 a.m.) naps. This factor will be referred to as Time (early versus late). For some analyses data from the participant's first night in the lab will be compared to the data from her second night in the lab (usually one week apart). This factor will be referred to as Week (first visit versus second visit). All power data were measured at C4 and they are expressed as means within each Division (quartile). All slope change data are presented as a ratio of actual slope changes divided by the maximum number of slope changes possible within each division. This was done to correct for differing lengths of sleep onset latencies. All sleep scoring was done at C4 in 5 second epochs using the Hori 9 stage system.

Analysis of the data from the Delta band can sometimes prove to be problematic due to contamination of the record from slow rolling eye movements (Coburn & Moreno,

1988). Visual inspection of the data indicated that there was eye movement artifact in some portions of some of the records. Because of this difficulty, only Theta, Alpha and Beta bands will be analyzed.

Missing Data

Because of the potential problems associated with such a large proportion of missing data (see Cohen & Cohen, 1983; Roth, 1994) analyses were undertaken to assess if the cases with missing information occurred in a random or selective fashion. The sleep logs, control measures and post-experiment questionnaires of all unused participants were analyzed and compared with those whose data were complete. The only significant differences which emerged were that the participants with missing data reported a later typical bedtime (1:00 a.m. on average) when compared to the other participants (12:15 a.m.) (t (14) = 2.51, p = .025) as well as lower subjective sleepiness (mean scores of 5.4 vs. 6.0) during the testing on the SSS (F (4,11) = 4.8, p = .017). The other 10 items tested from the sleep logs as well as 7 items from the post-experiment questionnaire and scores on the VASS, AAT and oral temperature showed no significant differences. There were also no Group by Nap Type interactions for the VASS, AAT or oral temperature.

These results indicate that with regard to all control and questionnaire data, the participants with complete data did not differ from the other participants in any significant manner other than typical bedtime and subjective sleepiness.

Examination of the Sleep Onset Process: Primary Analyses

Post-Experiment Questionnaires

Hypothesis 4 regarding differing thought processes in the two nap tests was evaluated by using the post-experiment questionnaire data. As had been hypothesized, most participants reported more structured thoughts in the RTSW. Of the 5 participants who responded that they had more structured thoughts in one test than the other, all 5 reported more structured thoughts in the RTSW. Conversely, 4 of 5 participants who answered the question concerning the presence of dream like thoughts indicated that these dream like thoughts were more likely to occur in the MSLT.

Participants' Effort in NapTests

Although not part of any formal hypotheses, subjective effort was also assessed through the post-experiment questionnaire. This was done because of the concern that participants would not exert sufficient effort in the RTSW to produce significant differences between the two nap types.

Participants in this study felt that they did not perform as well in the RTSW as they did in the MSLT ($t(6) = 2.97$, $p = .025$) and found the MSLT to be an easier test ($t(6) = 2.80$, $p = .03$). There was no significant difference in the effort reported between the two tests ($t(6) = 1.58$, $p = .17$). However, this non-significant result may be due to much greater variance in the reports of effort in the MSLT (range 2-7) than the RTSW (range 5-7). These results were virtually identical to analyses done on all 16 participants.

Demand Characteristics

Another concern was that the participants may exhibit demand characteristics because of the contradictory situation the RTSW placed them in. However, demand characteristics do not appear to have been a problem. Participants reported being convinced that the true purpose of the experiment had been explained to them. Half the sample (4 of 8 with complete data or 8 of 16 total) responded that they were completely convinced that the true purpose of the experiment was explained to them. Another 25% of the sample gave responses of 6 (out of 7 on a Likert scale with 7 being completely convinced). Only one participant indicated any doubt about the purpose of the experiment (4 out of 7 on the Likert). The remainder of the participants did not answer the question.

Control Measurements of Sleepiness, Arousal and Performance

A series of 2X2X2 (Nap Type X Week X Time) repeated measures ANOVAs were calculated for each of the 5 control measures (SSS, VASS, AAT, RT, oral temperature). The only significant difference in any measurement was a main effect for Time in the SSS ($\underline{F}$ (1,7) = 5.89, $\underline{p}$ = .046, η^2 = .105), VASS ($\underline{F}$ (1,7) = 7.49, $\underline{p}$ = .029, η^2 = .159), and AAT ($\underline{F}$ = (1,7) = 5.99, $\underline{p}$ = .044, η^2 = .042) (see tables 2-4). There were no significant interaction effects (see figures 3-7). The only significant effects were that participants felt more sleepy (less aroused) later in the night. Therefore, these control measures indicated that there was no need for concern regarding differences in sleepiness, arousal or ability to perform between the testing sessions involving the RTSW and MSLT.

Table 2

Summary ANOVA table for Stanford Sleepiness Scale (SSS) Scores

Source	df	SS	MS	F	p	η^2
Subjects	7	7.75	1.11			
Nap Type	1	.06	.06	.64	.45	
Within Cells (Nap Type)	7	.69	.10			
Time	1	4.00	4.00	5.89	.046	.105
Within Cells (Time)	7	4.75	.68			
Week	1	.06	.06	.05	.84	
Within Cells (Week)	7	9.69	1.38			
Nap Type X Time	1	.06	.06	.64	.45	
Within Cells (N X T)	7	.69	.10			
Nap Type X Week	1	1.00	1.00	1.87	.21	
Within Cells (N X W)	7	3.75	.54			
Time X Week	1	.06	.06	.26	.63	
Within Cells (T X W)	7	1.69	.24			
Nap Type X Time X Week	1	.00	.00	.00	1.0	
Within Cells (N X T X W)	7	3.75	.54			
Total	63	38				

Note: The following information is provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory a sufficient number of decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

Table 3

Summary ANOVA table for Visual Analogue Sleepiness Scale (VASS) Scores

Source	df	SS	MS	F	p	η^2
Subjects	7	2065.44	295.06			
Nap Type	1	33.06	33.06	1.21	.31	
Within Cells (Nap Type)	7	191.94	27.42			
Time	1	1190.25	1190.25	7.49	.03	.159
Within Cells (Time)	7	1112.25	158.89			
Week	1	18.06	18.06	.11	.75	
Within Cells (Week)	7	1152.44	164.63			
Nap Type X Time	1	30.25	30.25	.86	.38	
Within Cells (N X T)	7	246.75	35.25			
Nap Type X Week	1	232.56	232.56	4.70	.067	
Within Cells (N X W)	7	346.44	49.49			
Time X Week	1	2.25	2.25	.05	.83	
Within Cells (T X W)	7	316.25	45.18			
Nap Type X Time X Week	1	.25	.25	.00	.96	
Within Cells (N X T X W)	7	545.75	77.96			
Total	63	7483.94				

Note: The following information is provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for

Table 4

Summary ANOVA table for Alpha Attenuation Test (AAT) Scores

Source	df	SS	MS	F	p	η^2
Subjects	7	76.18	10.88			
Nap Type	1	.13	.13	1.65	.24	
Within Cells (Nap Type)	7	.53	.08			
Time	1	5.45	5.45	5.99	.044	.042
Within Cells (Time)	7	6.37	.91			
Week	1	1.71	1.71	.85	.39	
Within Cells (Week)	7	14.16	2.02			
Nap Type X Time	1	.74	.74	2.56	.15	
Within Cells (N X T)	7	2.02	.74			
Nap Type X Week	1	.05	.05	.03	.87	
Within Cells (N X W)	7	13.18	1.88			
Time X Week	1	.49	.49	.73	.42	
Within Cells (T X W)	7	4.70	.67			
Nap Type X Time X Week	1	.81	.81	1.92	.21	
Within Cells (N X T X W)	7	2.94	.42			
Total	63	129.46				

Note: The following information is provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for

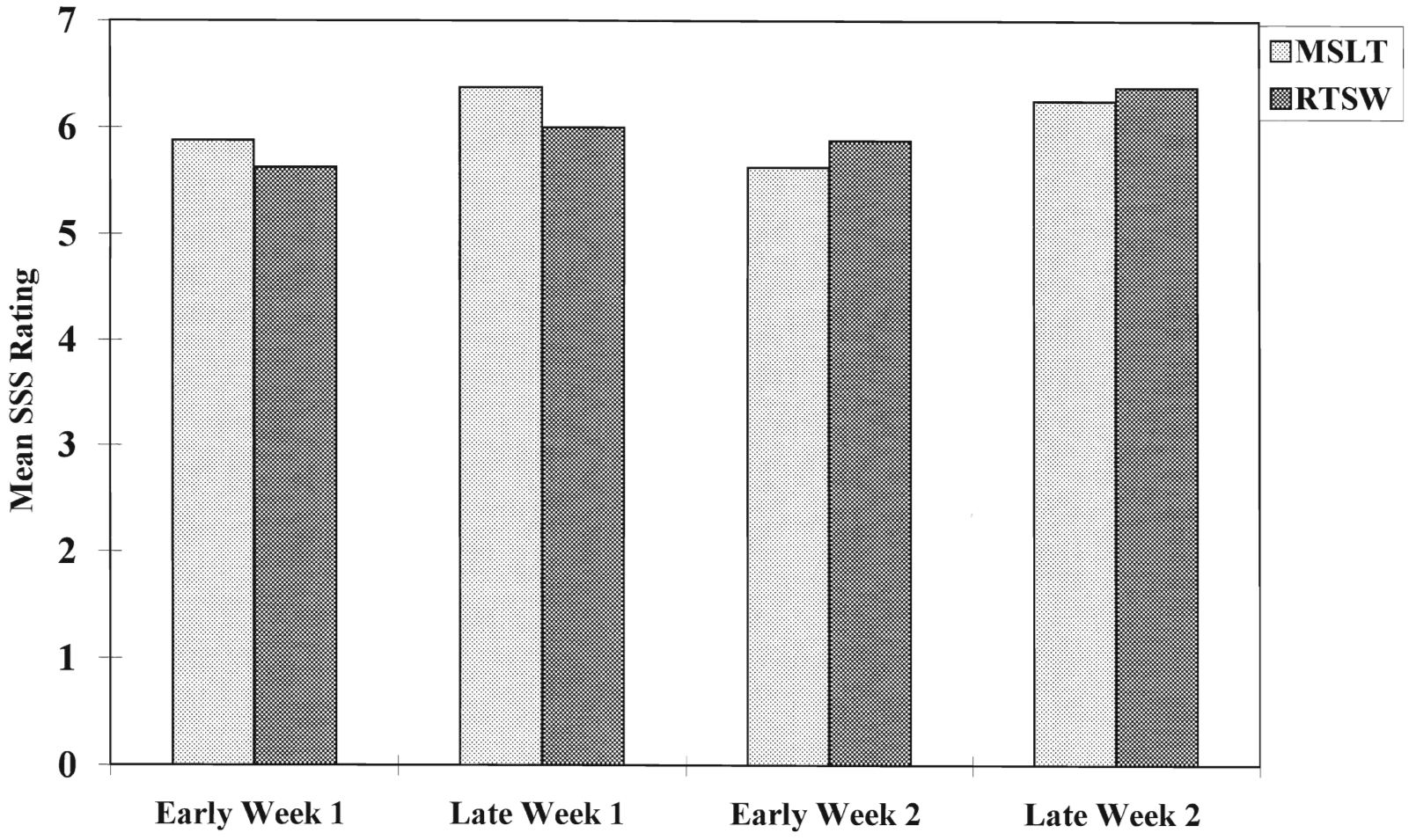

Stanford Sleepiness Scale (SSS) for each Type of Nap
Mean SSS Rating
7
6
5
4
3
2
1
0
MSLT
RTSW
Early Week 1
Late Week 1
Early Week 2
Late Week 2

Figure 3

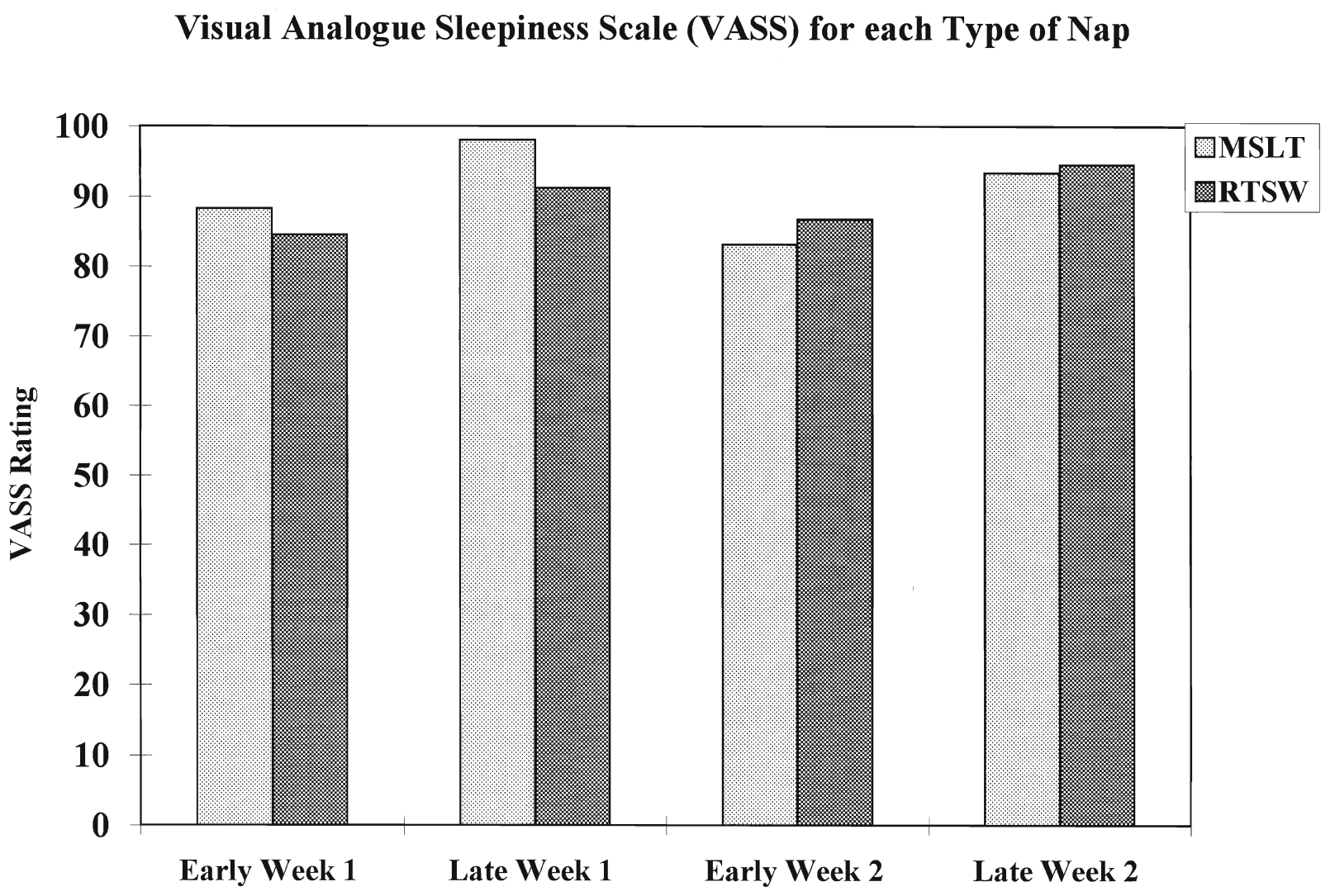
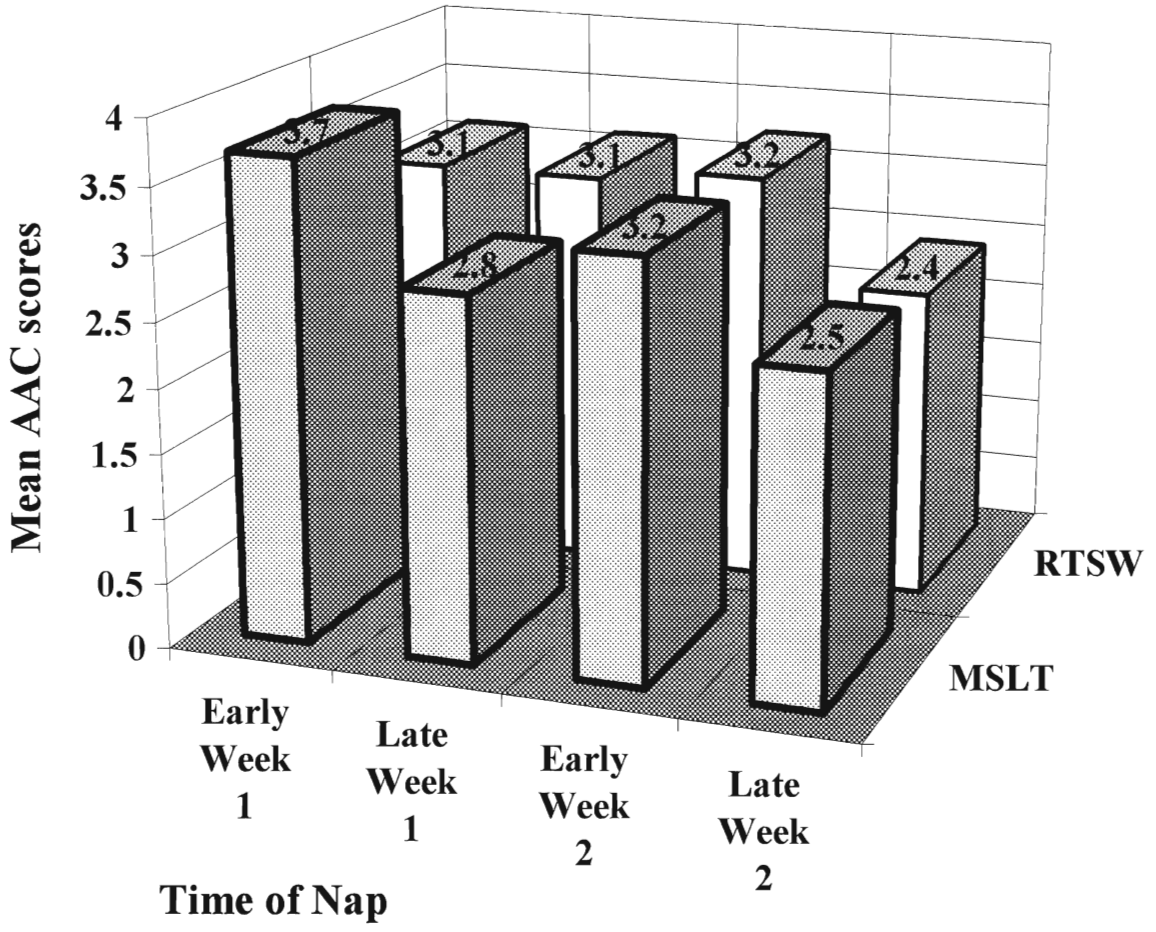

Visual Analogue Sleepiness Scale (VASS) for each Type of Nap
VASS Rating
100
90
80
70
60
50
40
30
20
10
0
MSLT
RTSW
Early Week 1
Late Week 1
Early Week 2
Late Week 2

Figure 4

Alpha Attenuation Coeffiecients for each Type of Nap



Main Effect of Time
F(1,7) = 5.99, p = .04

Figure 5

Figure 6

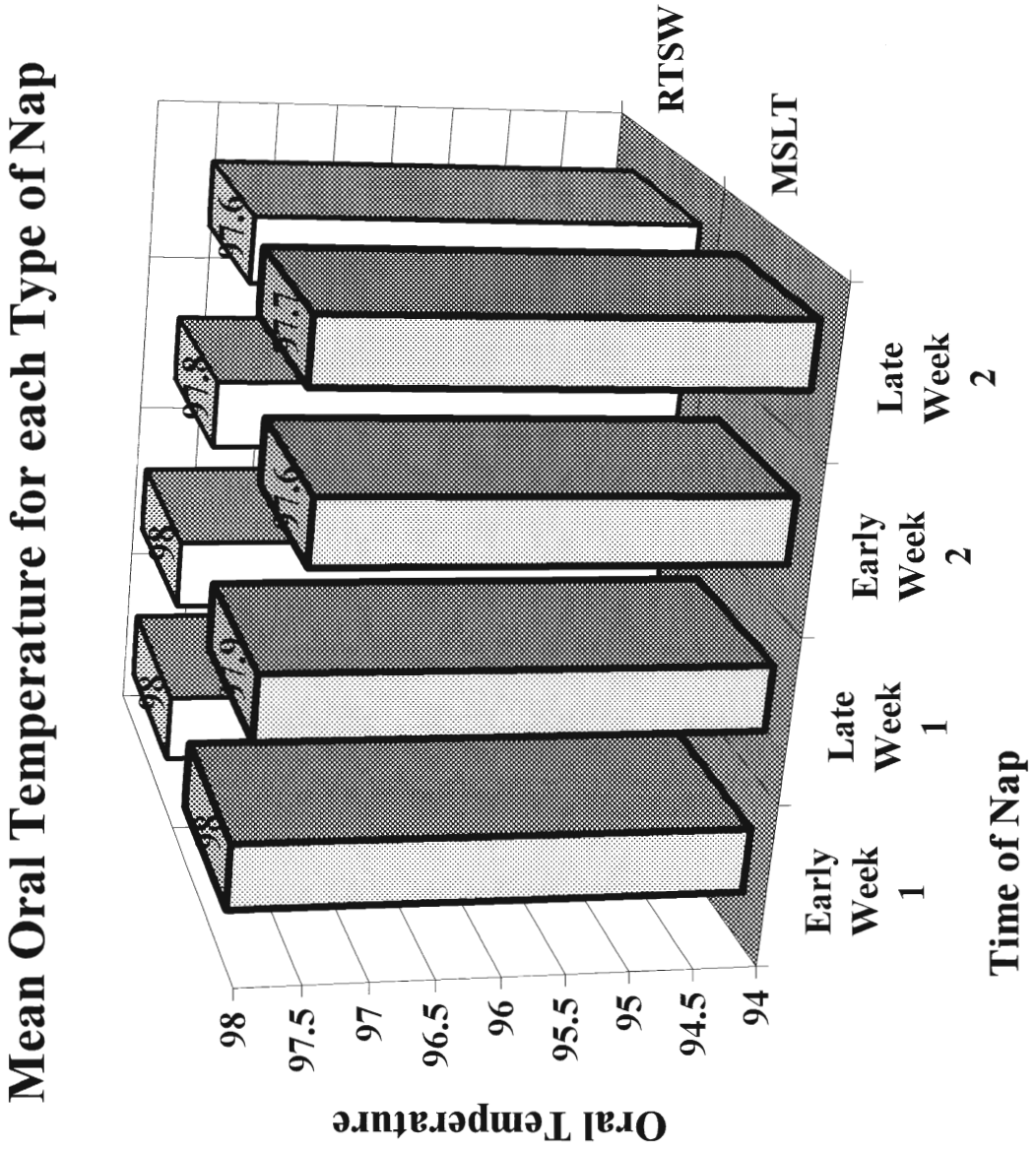
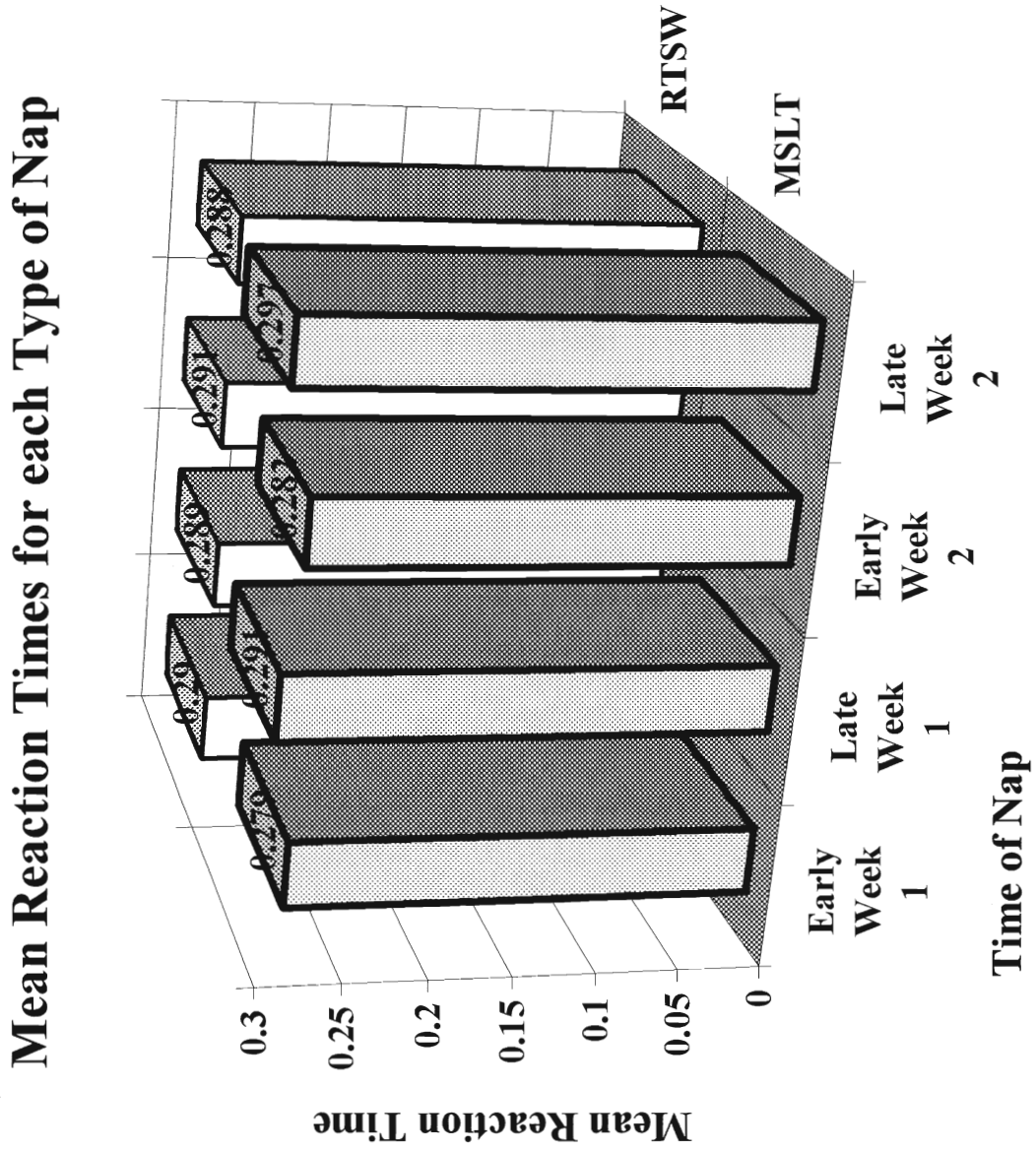

Mean Oral Temperature for each Type of Nap
Oral Temperature
98
97.5
97
96.5
96
95.5
95
94.5
94
98
97.9
98
97.6
97.8
97.7
97.6
RTSW
MSLT
Early Week 1
Late Week 1
Early Week 2
Late Week 2
Time of Nap

Figure 7


Mean Reaction Times for each Type of Nap
Mean Reaction Time
0.3
0.25
0.2
0.15
0.1
0.05
0
0.279
0.291
0.282
0.297
0.288
RTSW
MSLT
Early Week 1
Late Week 1
Early Week 2
Late Week 2
Time of Nap

Testing for Effects of Night in Lab

Due to the small number of participants and the number of variables in each analysis (32), it became necessary to test for any effect of night independently. There were no hypotheses which involved any effect of night (first vs. second) and because the counterbalancing measures were reasonably well preserved despite the large amount of missing data (5 participants had format 1, 3 had format 2), paired t tests were computed for each pair of relevant variables for all power and slope change data. Of 256 paired t tests only 13 reached significance. These did not follow any discernable pattern and were likely due to chance. Therefore, early and late naps of each type were averaged across weeks to yield mean scores for early MSLTs and RTSWs (12:00 or 1:00a.m.) as well as late MSLTs and RTSWs (2:00 and 3:00 a.m.). All naps were also divided into quartiles to yield 4 levels of a Division factor for both slope changes and power data. Unless otherwise stated, all tests involving power data or slope changes will be calculated using 2X2X4 (Nap Type X Time X Division) repeated measures ANOVAs.

Because of the potential problem of increased Type I error associated with analyses using repeated measures ANOVAs with more than two factors (Vasey & Thayer, 1987), Greenhouse-Geisser epsilons were calculated for all significant results. All reported effects retained significance levels of under .08 after adjustment using the Greenhouse-Geisser epsilon correction. Epsilons and corrected significance levels are indicated in the ANOVA summary tables while original degrees of freedom and original significance levels are reported in the text.

Sleep Onset Latencies

A doubly multivariate repeated measures MANOVA revealed that, as predicted, participants took significantly longer to reach predominately Hori stage 9 sleep (4 of 6 epochs) in the RTSW compared to the MSLT ($F(4,4) = 30.5$, $p = .003$). Further analysis using Nap Type X Week of testing X Time of nap (early vs. late naps) in a within subject ANOVA also revealed a significant main effect of Nap Type ($F(1,7) = 10.98$, $p = .013$, $\eta^2 = .029$). Participants reached stage 9 (Hori) more quickly later in the night (see table 5 and figure 8). These data support the hypothesis (1) that the intention to remain awake will result in longer sleep onset latencies. This increase in sleep onset latency was not due to increased movement time in the RTSW because there was actually a higher percentage of time in bed attributed to movement time in the MSLT (10%) than in the RTSW (7.5%) ($F(1,7) = 5.0$, $p = .06$) (see figure 9).

Analysis of Slope Changes

Hori Stage Changes

As predicted, there were significantly more decreases in Hori sleep stages per unit time[4] (i.e., a move toward wakefulness) in the RTSW ($F(1,7) = 6.37$, $p = .04$, $\eta^2 = .032$) (see table 6 and figure 10). There were also more decreases in stage later in each nap (a main effect of Division) ($F(3,21) = 9.16$, $p < .001$, $\eta^2 = .30$) (see table 6 and figure 11). There were no significant interactions (Nap Type X Time, Time X Division, Nap Type X Division).

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[4] Recall that slope changes are expressed as a ratio of actual changes/maximum number of changes to correct for differing sleep onset latencies.

Table 5

Summary ANOVA table for Sleep Onset Latencies

Source	df	SS	MS	F	p	η^2
Subjects	7	72384.86	10340.69			
Nap Type	1	4505.77	4505.77	10.98	.013	.029
Within Cells (Nap Type)	7	2871.86	410.27			
Time	1	23677.52	23677.52	87.81	<.001	.15
Within Cells (Time)	7	1887.61	269.66			
Week	1	4273.89	4273.89	1.29	.29	
Within Cells (Week)	7	23180.23	3311.46			
Nap Type X Time	1	58.14	58.14	.09	.78	
Within Cells (N X T)	7	4706.48	672.35			
Nap Type X Week	1	415.14	415.14	.60	.46	
Within Cells (N X W)	7	4864.48	694.93			
Time X Week	1	594.14	594.14	.91	.37	
Within Cells (T X W)	7	4584.98	655.00			
Nap Type X Time X Week	1	722.27	722.27	.54	.49	
Within Cells (N X T X W)	7	9338.36	1334.05			
Total	63	158065.73				

Note: The following information is provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for

Main Effects of Nap Type and Time of Night on Sleep Onset Latencies

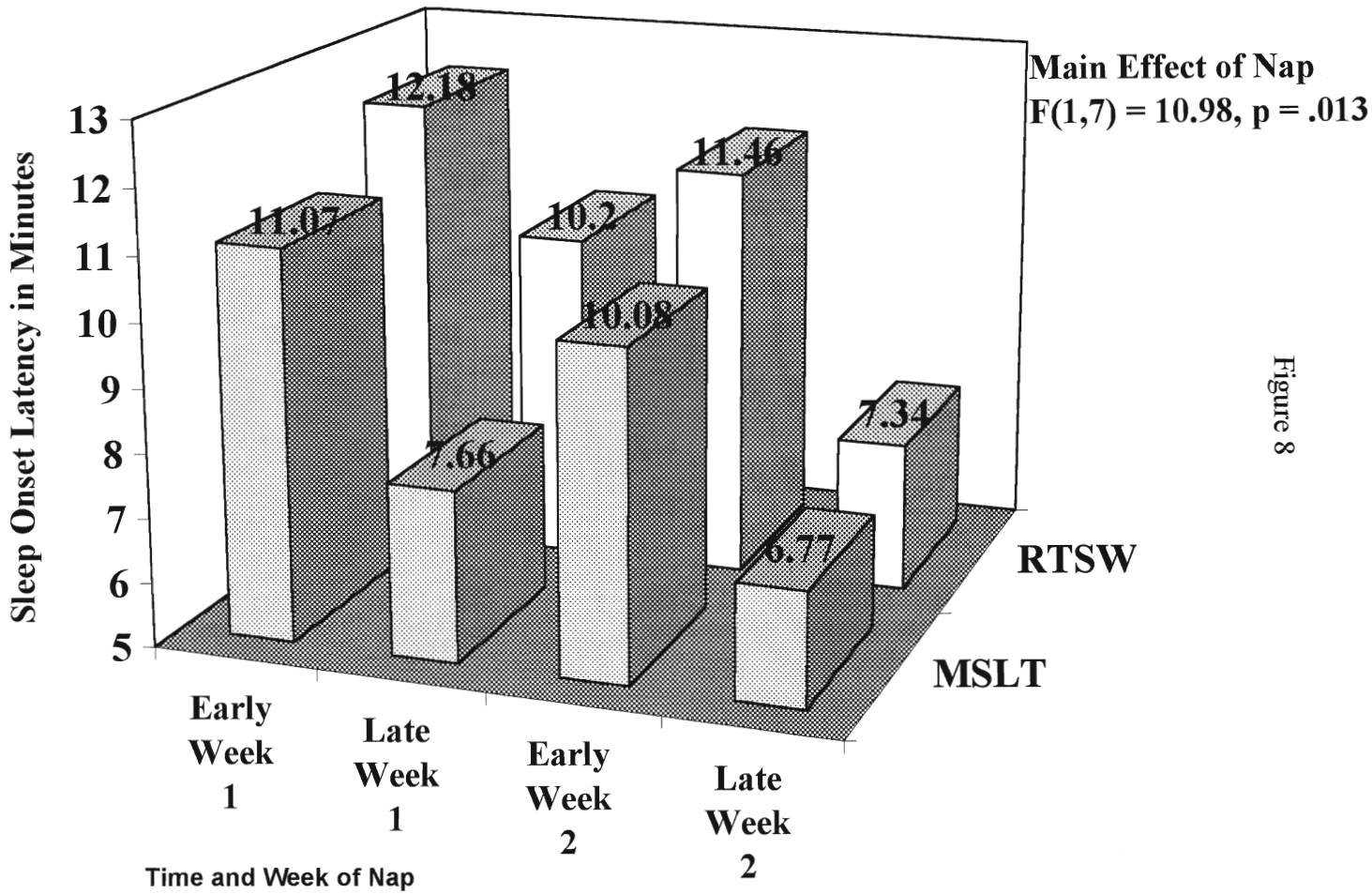


Figure 8

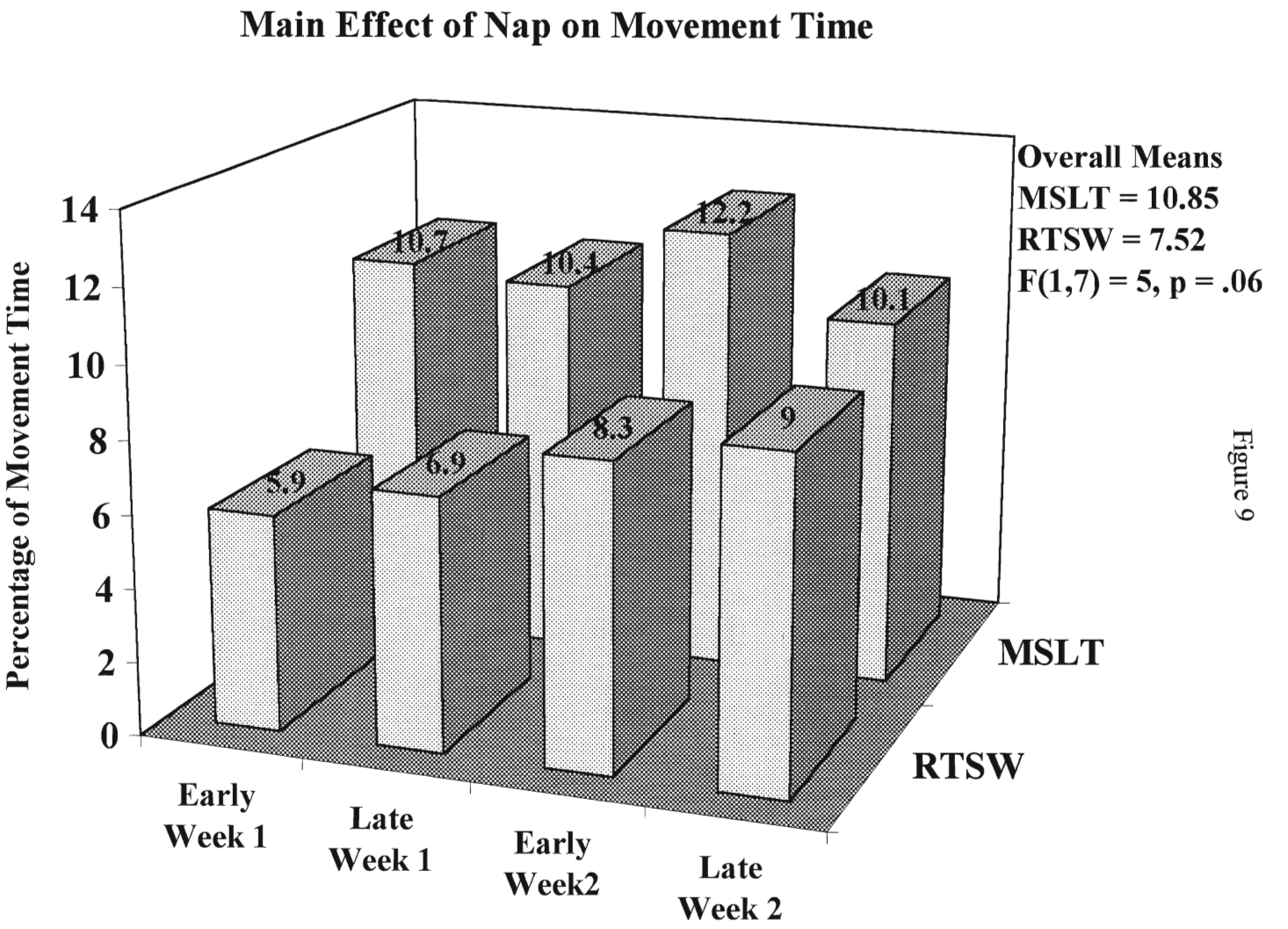

Main Effect of Nap on Movement Time
Percentage of Movement Time
14
12
10
8
6
4
2
0
10.7
10.4
12.2
10.1
5.9
6.9
8.3
9
Overall Means
MSLT = 10.85
RTSW = 7.52
F(1,7) = 5, p = .06
MSLT
RTSW
Early Week 1
Late Week 1
Early Week2
Late Week 2

Figure 9

Table 6

Summary ANOVA table for Hori Slope Changes in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	.13	.02				
Nap Type	1	.06	.06	6.37	.040	.032	
Within Cells (Nap Type)	7	.07	.01				
Time	1	.00	.00	.03	.858		
Within Cells (Time)	7	.07	.01				
Division	3	.55	.18	9.16**	<.001	.30	.514
Within Cells (Division)	21	.42	.02				
Nap Type X Time	1	.00	.00	1.47	.264		
Within Cells (N X T)	7	.02	.00				
Nap Type X Division	3	.05	.02	1.84	.171		
Within Cells (N X D)	21	.18	.01				
Time X Division	3	.02	.01	1.30	.299		
Within Cells (T X D)	21	.13	.01				
Nap Type X Time X Division	3	.02	.01	.80	.508		
Within Cells (N X T X D)	21	.13	.01				
Total	127	1.85					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

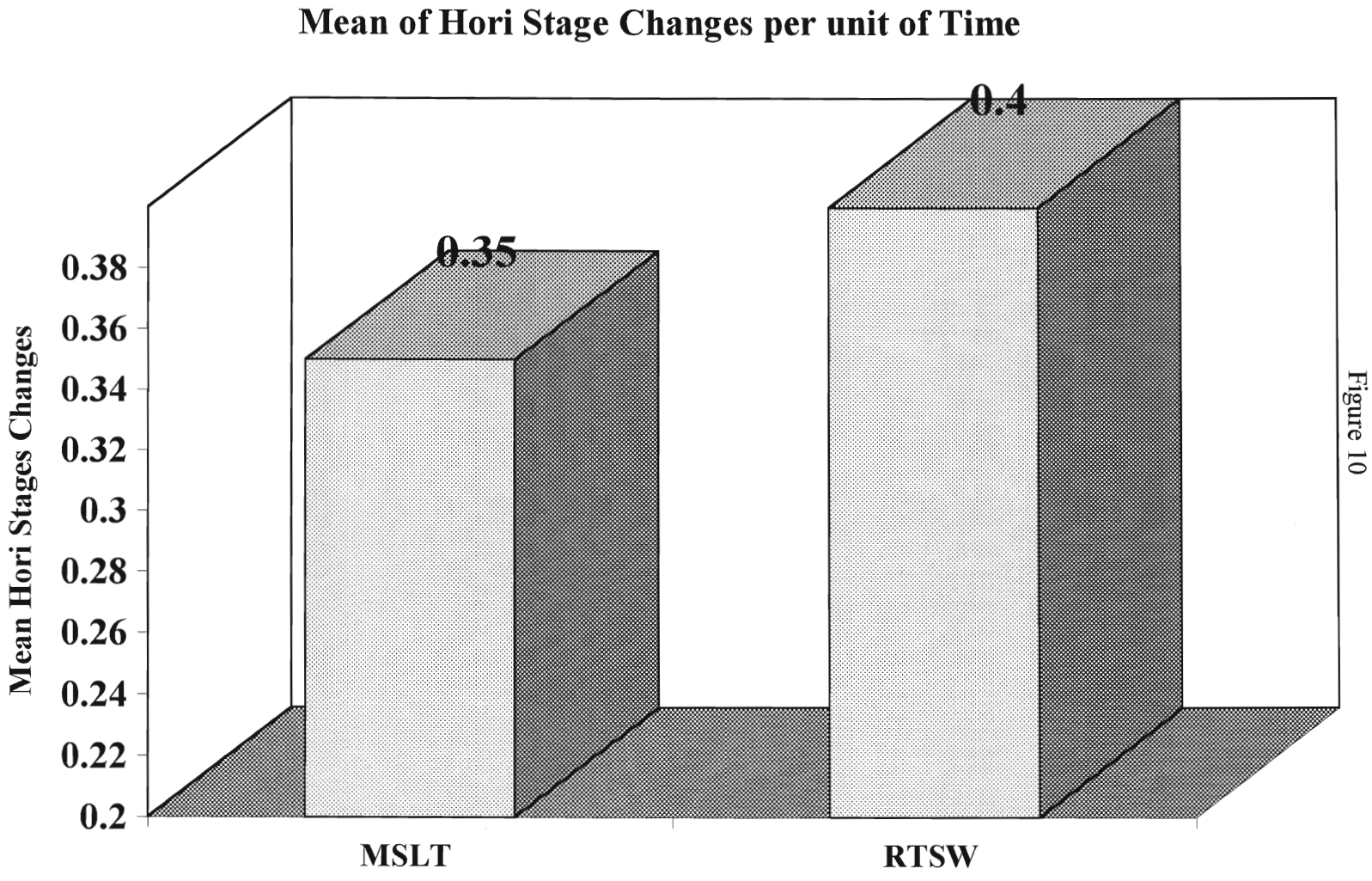


Figure 10

F(1,7) = 6.37, p = .04

Main Effects of Nap and Division for Hori Stage Changes

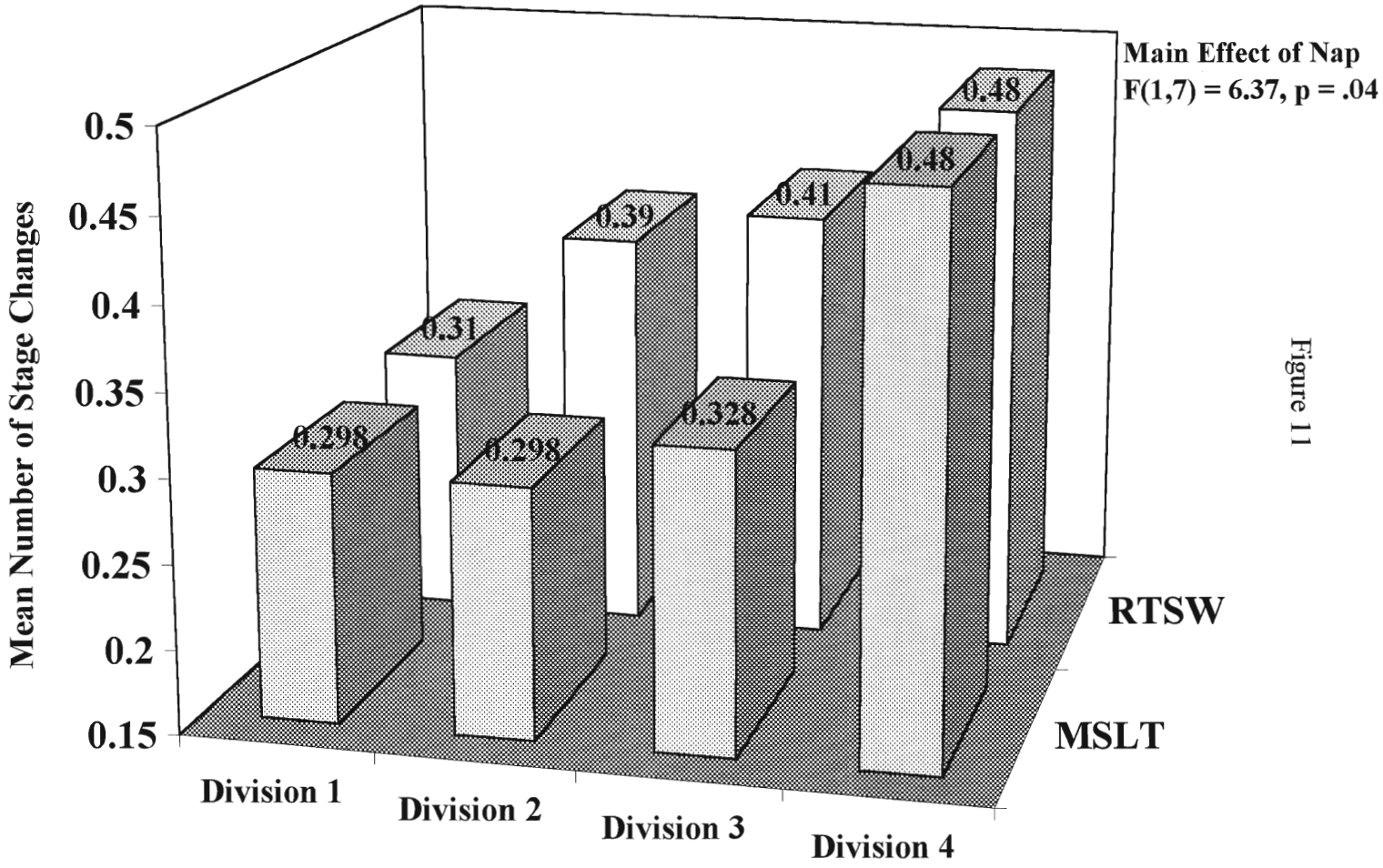


Figure 11

Slope Changes in Alpha Power

Hypothesis 2 was not supported for the Alpha band. There was only one main effect of Division in the slope changes of the alpha power. There were fewer slope changes in the later Divisions (closer to sleep) (F (3,21) = 5.9, p = .004, η^2 = .216) (see table 7) suggesting that there were fewer oscillations in arousal as sleep approached.

Slope Changes in Theta Power

Similar to the effects in Alpha stated above, there was a main effect for Division except that in this case there were more slope changes later in the sleep onset period in Theta power (F (3,21) = 26.36, p < .001, η^2 = .347) (see table 8 and figure 12). There was also a Nap Type by Division interaction such that there were more slope changes during the last Division in the MSLT and more slope changes in the RTSW early in the sleep onset period (F (3,21) = 4.64, p = .012, η^2 = .025) (see table 8 and figure 12).

These differential oscillations in Theta power may represent an effect of the different intentions in the two nap tests. However, this result is counter-intuitive and contrary to hypothesis 3 because the changes in slope are increasing more rapidly in the MSLT during the sleep onset period. The effort being exerted to remain awake should have produced more slope changes in the RTSW. Perhaps high variability in Theta power is the natural pattern during the transition from late Rechtschaffen and Kales (1968) stage 1 to early stage 2 sleep. If this were the case, then fewer slope changes late in the sleep onset period may represent a dampening of this normally high variability.

Table 7

Summary ANOVA table for Alpha Slope Changes in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	.75	.11				
Nap Type	1	.01	.01	2.47	.160		
Within Cells (Nap Type)	7	.04	.01				
Time	1	.01	.01	.92	.370		
Within Cells (Time)	7	.05	.01				
Division	3	.64	.21	5.90*	.004	.216	.586
Within Cells (Division)	21	.75	.04				
Nap Type X Time	1	.00	.00	.54	.485		
Within Cells (N X T)	7	.03	.00				
Nap Type X Division	3	.02	.01	.46	.713		
Within Cells (N X D)	21	.28	.01				
Time X Division	3	.05	.02	2.01	.143		
Within Cells (T X D)	21	.18	.01				
Nap Type X Time X Division	3	.02	.01	.89	.460		
Within Cells (N X T X D)	21	.13	.01				
Total	127	2.96					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

Table 8

Summary ANOVA table for Theta Slope Changes in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	.38	.05				
Nap Type	1	.00	.00	.82	.395		
Within Cells (Nap Type)	7	.04	.01				
Time	1	.00	.00	.05	.834		
Within Cells (Time)	7	.12	.02				
Division	3	.83	.28	26.36**	<.001	.347	.765
Within Cells (Division)	21	.22	.01				
Nap Type X Time	1	.00	.00	.16	.702		
Within Cells (N X T)	7	.21	.03				
Nap Type X Division	3	.06	.02	4.64*	.012	.025	.756
Within Cells (N X D)	21	.09	.00				
Time X Division	3	.02	.01	.57	.64		
Within Cells (T X D)	21	.23	.01				
Nap Type X Time X Division	3	.01	.00	.54	.662		
Within Cells (N X T X D)	21	.10	.00				
Total	127	2.39					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

Nap by Division Interaction for Theta Slope Change in Entire Record

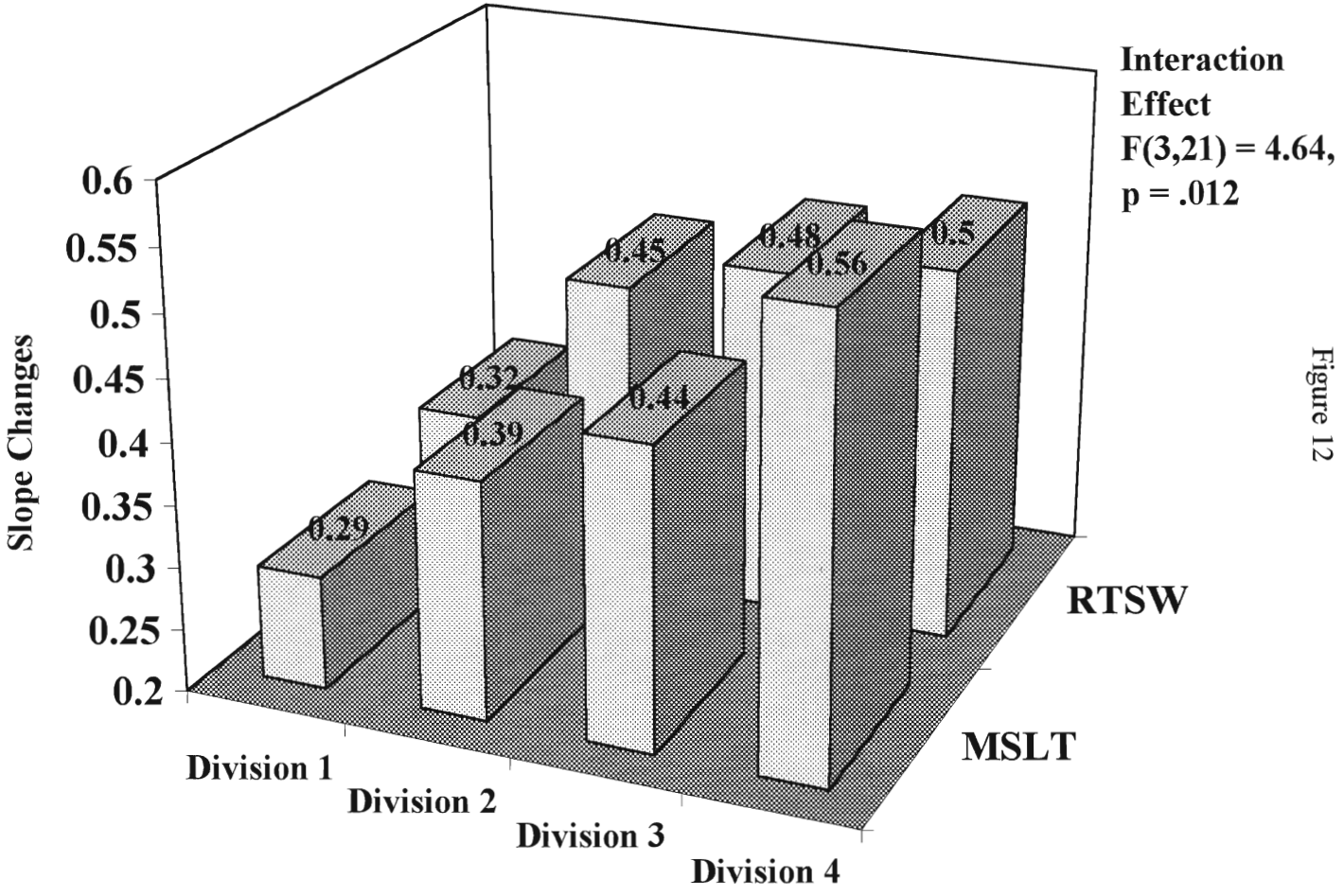


Figure 12

Slope changes in Beta Power

There were no significant main effects or interactions in the Beta range.

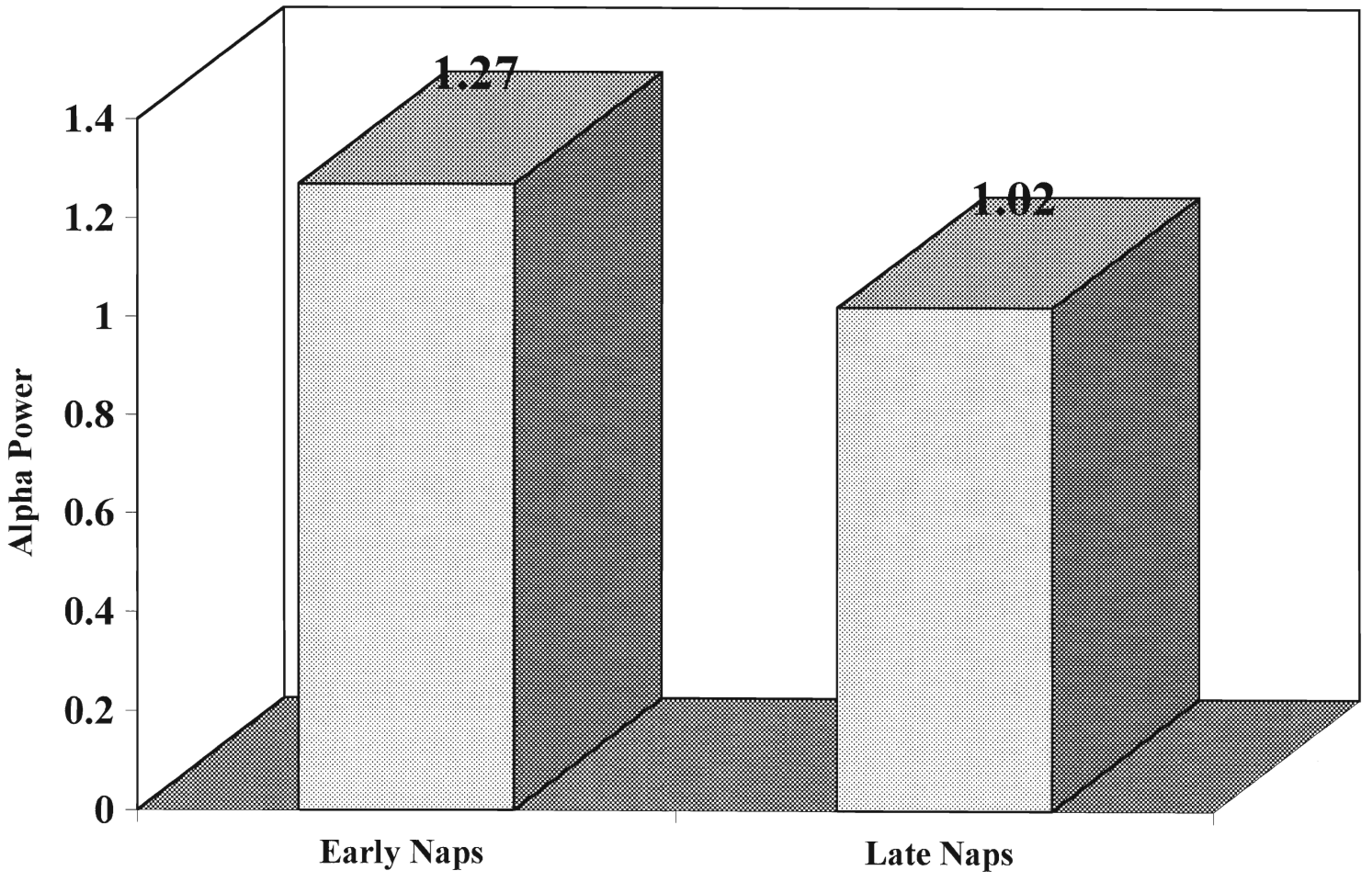
Analysis of Power Data

Alpha Power

There was significantly more Alpha power in the early sessions (12:00 and 1:00 a.m.) compared to the late sessions (2:00 and 3:00 a.m.)(see figure 13) ($\underline{F}$ (1,7) = 9.36, $\underline{p}$ = .02, η^2 = .016) (see table 9). This result is consistent with the subjective ratings of increased sleepiness during the later sessions. There was also higher power in the first Divisions than those nearer to sleep onset ($\underline{F}$ (3,21) = 10.45, $\underline{p}$ < .001, η^2 = .35) (see figure 14). There was also a significant Time by Division interaction ($\underline{F}$ (3,21) = 3.51, $\underline{p}$ = .03, η^2 = .007). Alpha power dropped more quickly in the 2:00 and 3:00 a.m. naps than in the early naps (see figure 14). This is also consistent with expected increased sleepiness later in the night and demonstrates the usefulness of Alpha in detecting arousal levels. However, the hypothesis concerning a Nap Type by Division interaction was not supported ($\underline{F}$ (3,21) = .6, ns).

Theta Power

The hypothesized interaction between Nap Type and Division was not supported for Theta power ($\underline{F}$ (3,21) = 1.57, $\underline{p}$ = .22). There was a Division effect with more Theta power later within each nap ($\underline{F}$ (1,7) = 40.06, $\underline{p}$ < .001, η^2 = .59), and a trend towards more Theta power in the later naps ($\underline{F}$ (1,7) = 5.05, $\underline{p}$ = .06) (see table 10).



F(1,7) = 9.36, p = .02

Figure 13

Table 9

Summary ANOVA table for Alpha Power in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	45.25	6.46				
Nap Type	1	.01	.01	.20	.669		
Within Cells (Nap Type)	7	.23	.03				
Time	1	2.09	2.09	9.36	.018		
Within Cells (Time)	7	1.56	.22				
Division	3	45.94	15.31	10.45*	<.001	.35	.356
Within Cells (Division)	21	30.78	1.47				
Nap Type X Time	1	.14	.14	1.64	.241		
Within Cells (N X T)	7	.58	.08				
Nap Type X Division	3	.05	.02	.56	.649		
Within Cells (N X D)	21	.64	.03				
Time X Division	3	.98	.33	3.51	.033	.007	.630
Within Cells (T X D)	21	1.96	.09				
Nap Type X Time X Division	3	.25	.08	1.97	.150		
Within Cells (N X T X D)	21	.90	.04				
Total	127	131.36					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)

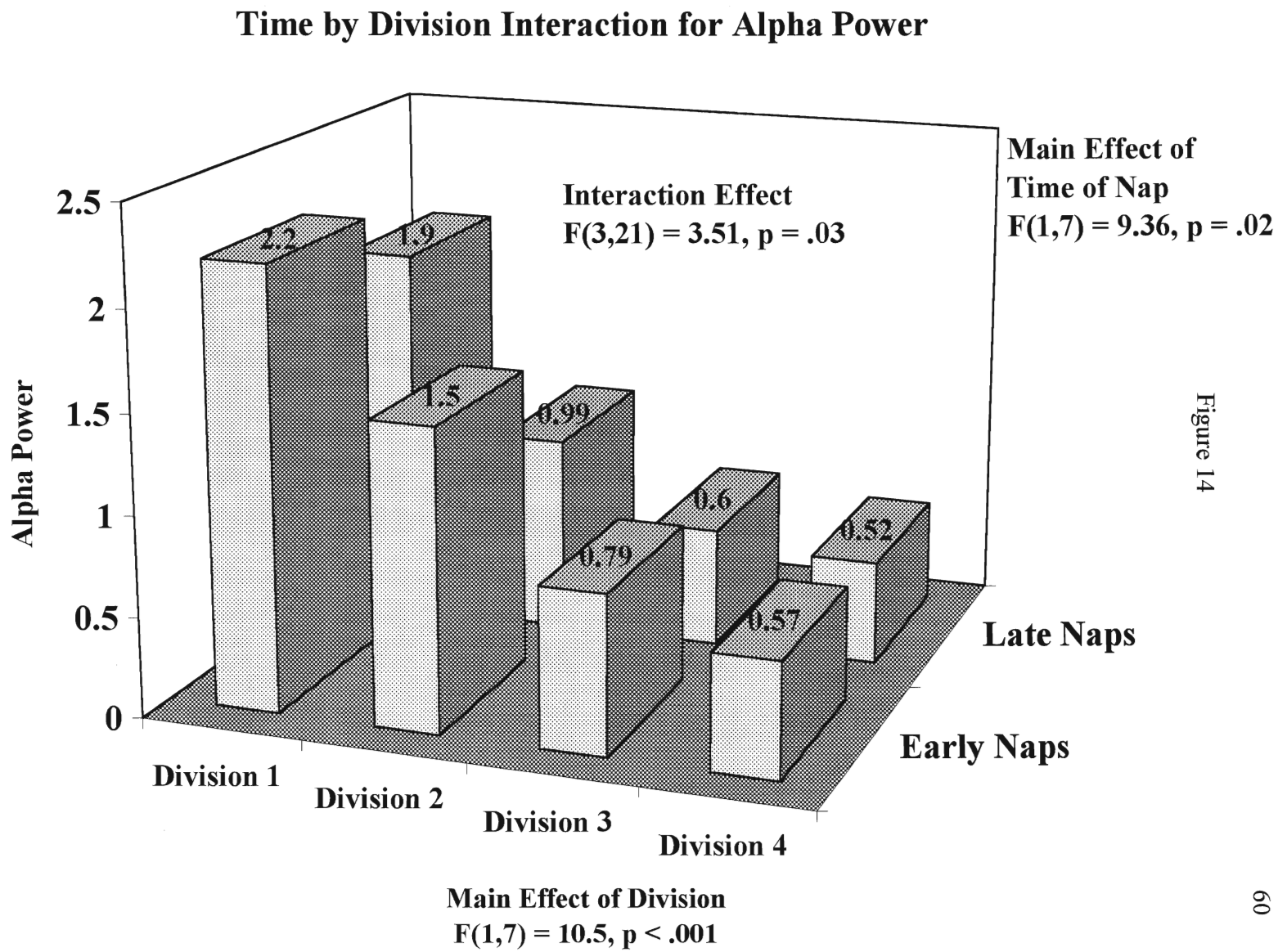

Time by Division Interaction for Alpha Power
Interaction Effect
F(3,21) = 3.51, p = .03
Main Effect of
Time of Nap
F(1,7) = 9.36, p = .02
Alpha Power
2.5
2
1.5
1
0.5
0
2.2
1.9
1.5
0.99
0.6
0.52
0.79
0.57
Late Naps
Early Naps
Division 1
Division 2
Division 3
Division 4
Main Effect of Division
F(1,7) = 10.5, p < .001

Figure 14

Table 10

Summary ANOVA table for Theta Power in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	6.98	1.00				
Nap Type	1	.16	.16	1.01	.348		
Within Cells (Nap Type)	7	1.11	.16				
Time	1	.52	.52	5.05	.059		
Within Cells (Time)	7	.72	.10				
Division	3	26.13	8.71	40.06**	<.001	.59	.432
Within Cells (Division)	21	4.57	.22				
Nap Type X Time	1	.03	.03	.58	.471		
Within Cells (N X T)	7	.32	.05				
Nap Type X Division	3	.23	.08	1.57	.225		
Within Cells (N X D)	21	1.02	.05				
Time X Division	3	.37	.12	2.01	.143		
Within Cells (T X D)	21	1.28	.06				
Nap Type X Time X Division	3	.01	.00	.07	.976		
Within Cells (N X T X D)	21	.76	.00				
Total	127	44.21					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)

Beta Power

There were trends towards higher Beta power in the RTSW (F (1,7) = 4.33, p = .08) and higher Beta power earlier in the night (F (1,7) = 5.12, p = .06). There was a significant main effect of Division with Beta power dropping during the sleep onset period (F (3,21) = 5.91, p = .004, η^2 = .10) as one would expect (see table 11).

Analysis of the Final 4.33 minutes prior to Stage 9 Consolidation

The sleep onset period for each participant was initially divided into quartiles to compensate for differing sleep onset latencies. To investigate whether the final stages of wakefulness differed across nap types and to completely eliminate the potential confound of using proportional data (Cohen & Cohen, 1983), the information from both naps was re-analyzed using the final 4 minutes and 20 seconds of each nap (the final 52, five second epochs). This time period was chosen because it reflected the maximum time for which a comparable analysis of all subjects could be carried out. All tests involving power data or slope changes for this time period were calculated using 2X2X4 (Nap Type X Time X Division) repeated measures ANOVAs and represent further analyses of hypothesis 2 (increased slope changes) and hypothesis 3 (delayed power changes in RTSW).

Table 11

Summary ANOVA table for Beta Power in Entire Record

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	2.21	.32				
Nap Type	1	.01	.01	4.33	.076		
Within Cells (Nap Type)	7	.01	.00				
Time	1	.10	.10	5.12	.058		
Within Cells (Time)	7	.14	.02				
Division	3	.32	.11	5.91*	.004	.10	.391
Within Cells (Division)	21	.38	.02				
Nap Type X Time	1	.01	.01	2.8	.138		
Within Cells (N X T)	7	.02	.00				
Nap Type X Division	3	.01	.00	2.12	.128		
Within Cells (N X D)	21	.03	.00				
Time X Division	3	.02	.01	2.19	.119		
Within Cells (T X D)	21	.06	.00				
Nap Type X Time X Division	3	.00	.00	1.97	.149		
Within Cells (N X T X D)	21	.02	.00				
Total	127	3.33					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

Slope Changes

Hori Stages (last 52 epochs)

In agreement with earlier analyses, there were main effects for Nap Type ($\underline{F}$ (1,7) = 9.45, $\underline{p}$ = .02, η^2 = .034) and Division ($\underline{F}$ (3,21) = 23.4, $\underline{p}$ < .001, η^2 = .319) (see table 12 and figure 15). In support of hypothesis 2 there were, on average, more Hori stage changes in the RTSW (mean = 2.6) than in the MSLT (mean = 2.3). There were also more stage changes as the participants moved closer to sleep.

Slope Changes in Alpha Power (last 52 epochs)

There were no main effects of Nap Type, Time or Division for Alpha slope changes. However, there was an interaction between Nap Type and Time of test ($\underline{F}$ (1,7) = 7.56, $\underline{p}$ = .03, η^2 = .041) (see table 13). The early MSLT tests had fewer slope changes in alpha power than the late MSLTs or any of the RTSW nap tests (see figure 16).

Slope Changes in Theta Power (last 52 epochs)

There were more slope changes later in the sleep onset period in Theta power ($\underline{F}$ (3,21) = 8.07, $\underline{p}$ = .001, η^2 = .211). There was also a significant Nap Type by Division interaction ($\underline{F}$ (3,21) = 3.55, $\underline{p}$ = .03, η^2 = .031) (see table 14). As in the entire sleep onset period, there were more slope changes in the RTSW in the first Divisions but more slope changes in the MSLT in the last Division (see figure 17). This result is contrary to hypothesis 2.

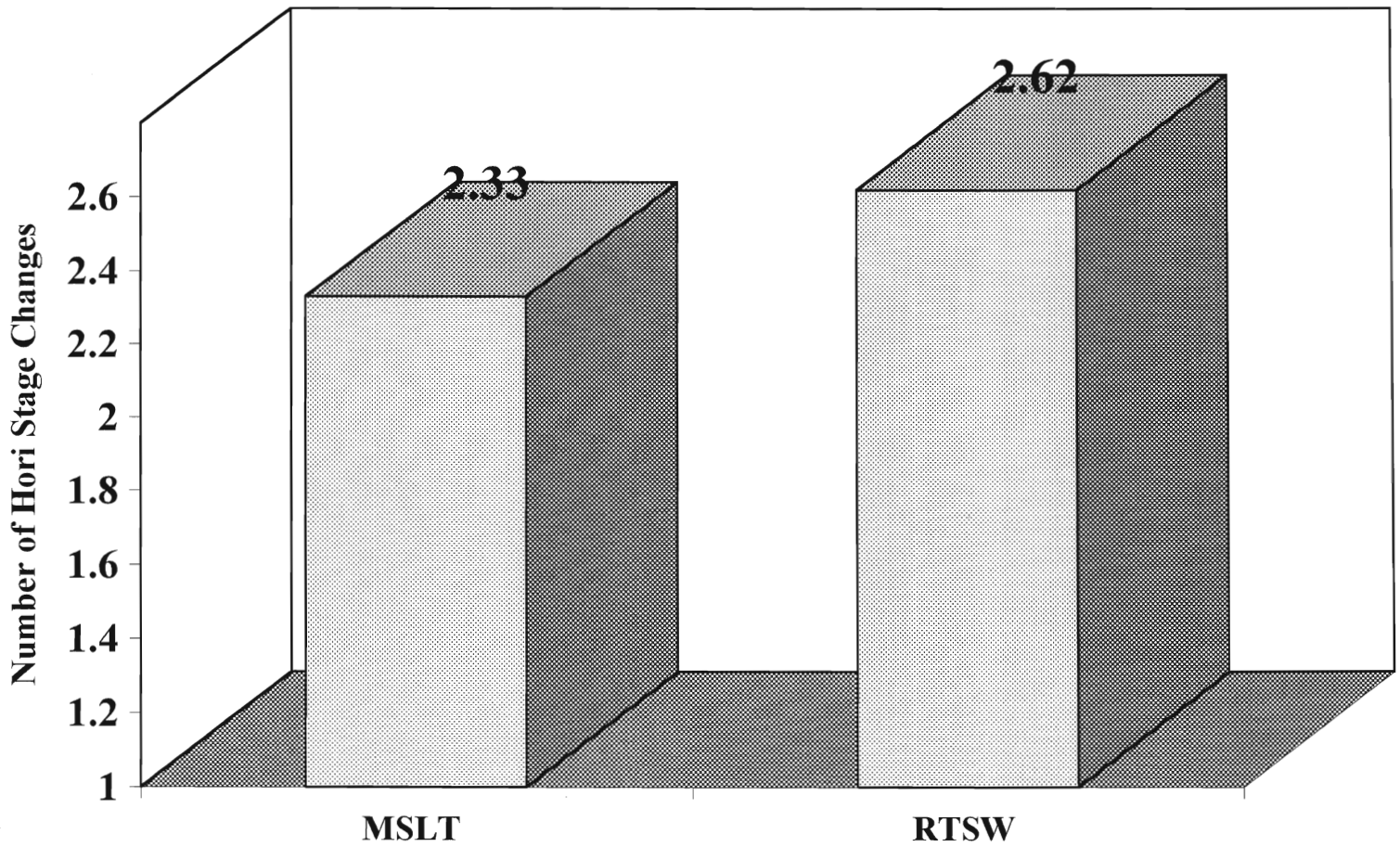
Table 12

Summary ANOVA table for Hori Stage Changes in Last 52 Epochs

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	24.03	3.43				
Nap Type	1	4.88	4.88	9.45	.018	.036	
Within Cells (Nap Type)	7	3.62	.52				
Time	1	.50	.50	.52	.495		
Within Cells (Time)	7	6.75	.96				
Division	3	43.34	14.45	23.40**	<.001	.319	.69
Within Cells (Division)	21	12.97	.62				
Nap Type X Time	1	.07	.07	.16	.703		
Within Cells (N X T)	7	3.12	.45				
Nap Type X Division	3	2.84	.95	2.14	.126		
Within Cells (N X D)	21	9.29	.44				
Time X Division	3	1.12	.37	.83	.493		
Within Cells (T X D)	21	9.5	.37				
Nap Type X Time X Division	3	.59	.20	.31	.816		
Within Cells (N X T X D)	21	13.10	.62				
Total	127	135.72					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)

Mean Number of Hori Stage Changes per Division during Last 52 Epochs



F(1,7) = 9.45, p = .02

Figure 15

Table 13

Summary ANOVA table for Alpha Slope Changes in Last 52 Epochs

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	9.15	1.31				
Nap Type	1	2.26	2.26	3.11	.121		
Within Cells (Nap Type)	7	5.09	.73				
Time	1	2.00	2.00	1.40	.275		
Within Cells (Time)	7	9.97	1.42				
Division	3	1.02	.34	.46	.713		
Within Cells (Division)	21	15.57	.74				
Nap Type X Time	1	3.78	3.78	7.56*	.03	.041	.64
Within Cells (N X T)	7	3.50	.50				
Nap Type X Division	3	.90	.30	.54	.60		
Within Cells (N X D)	21	11.63	.55				
Time X Division	3	.41	.14	.18	.908		
Within Cells (T X D)	21	15.75	.75				
Nap Type X Time X Division	3	1.19	.40	.82	.498		
Within Cells (N X T X D)	21	10.16	.48				
Total	127	92.38					

Note: The following three pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)

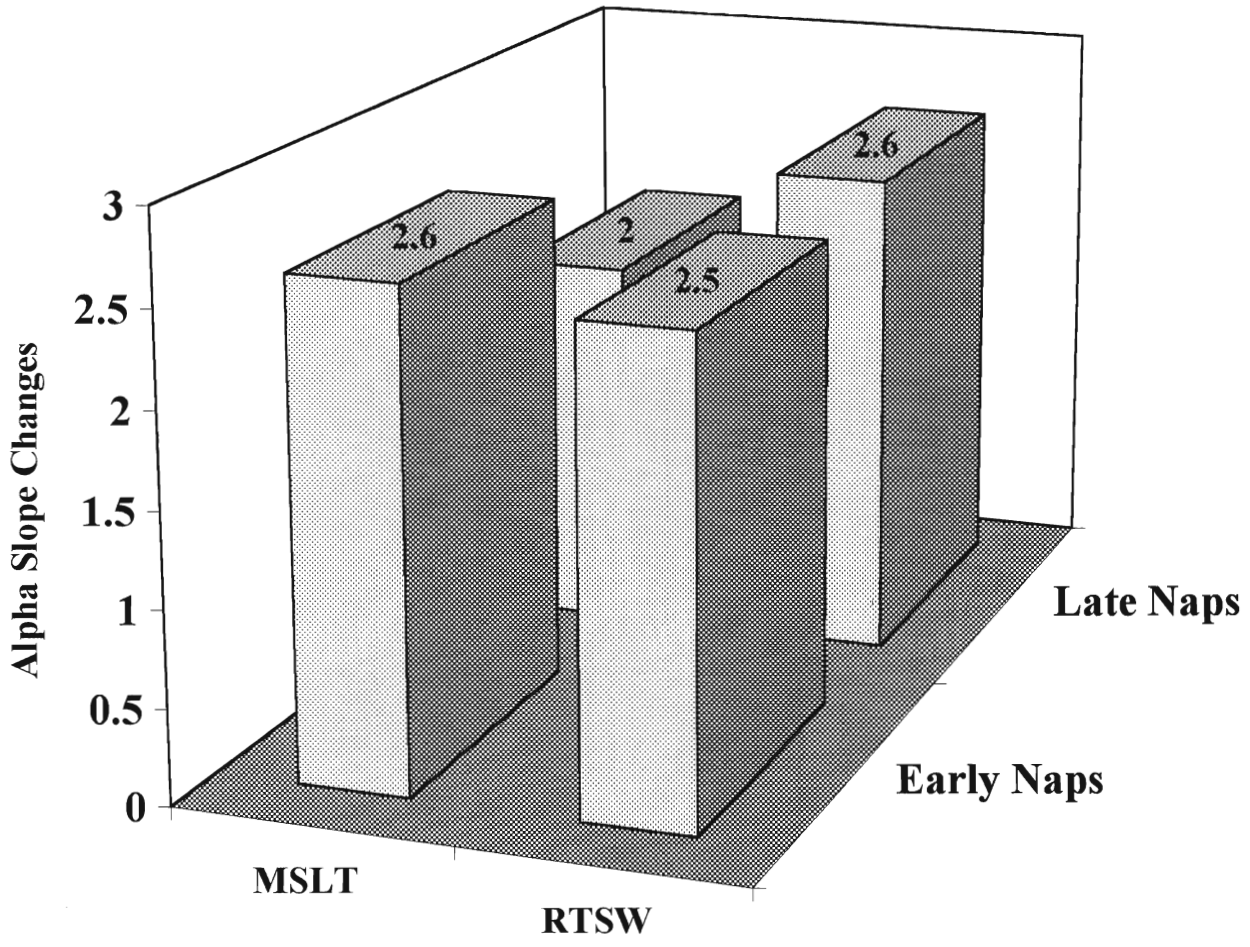

Nap by Time Interaction for Alpha Slope Changes in Last 52 Epochs
Alpha Slope Changes
3
2.5
2
1.5
1
0.5
0
2.6
2
2.5
2.6
Late Naps
Early Naps
MSLT
RTSW
Interaction
F(1,7) = 7.56, p = .03

Figure 16

Table 14

Summary ANOVA table for Theta Slope Changes in Last 52 Epochs

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	4.93	.70				
Nap Type	1	.07	.07	.20	.670		
Within Cells (Nap Type)	7	2.49	.36				
Time	1	.20	.20	.42	.537		
Within Cells (Time)	7	3.24	.46				
Division	3	18.27	6.09	8.07**	.001	.211	.71
Within Cells (Division)	21	15.85	.75				
Nap Type X Time	1	1.76	1.76	3.18	.118		
Within Cells (N X T)	7	3.87	.55				
Nap Type X Division	3	2.71	.90	3.55	.032	.031	.60
Within Cells (N X D)	21	5.35	.25				
Time X Division	3	1.52	.51	1.23	.323		
Within Cells (T X D)	21	8.66	.41				
Nap Type X Time X Division	3	.34	.11	.14	.937		
Within Cells (N X T X D)21	17.16	.82					
Total	127	86.42					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, ***p<.001

Nap by Division Interaction for Theta Slope Changes in Last 52 Epochs

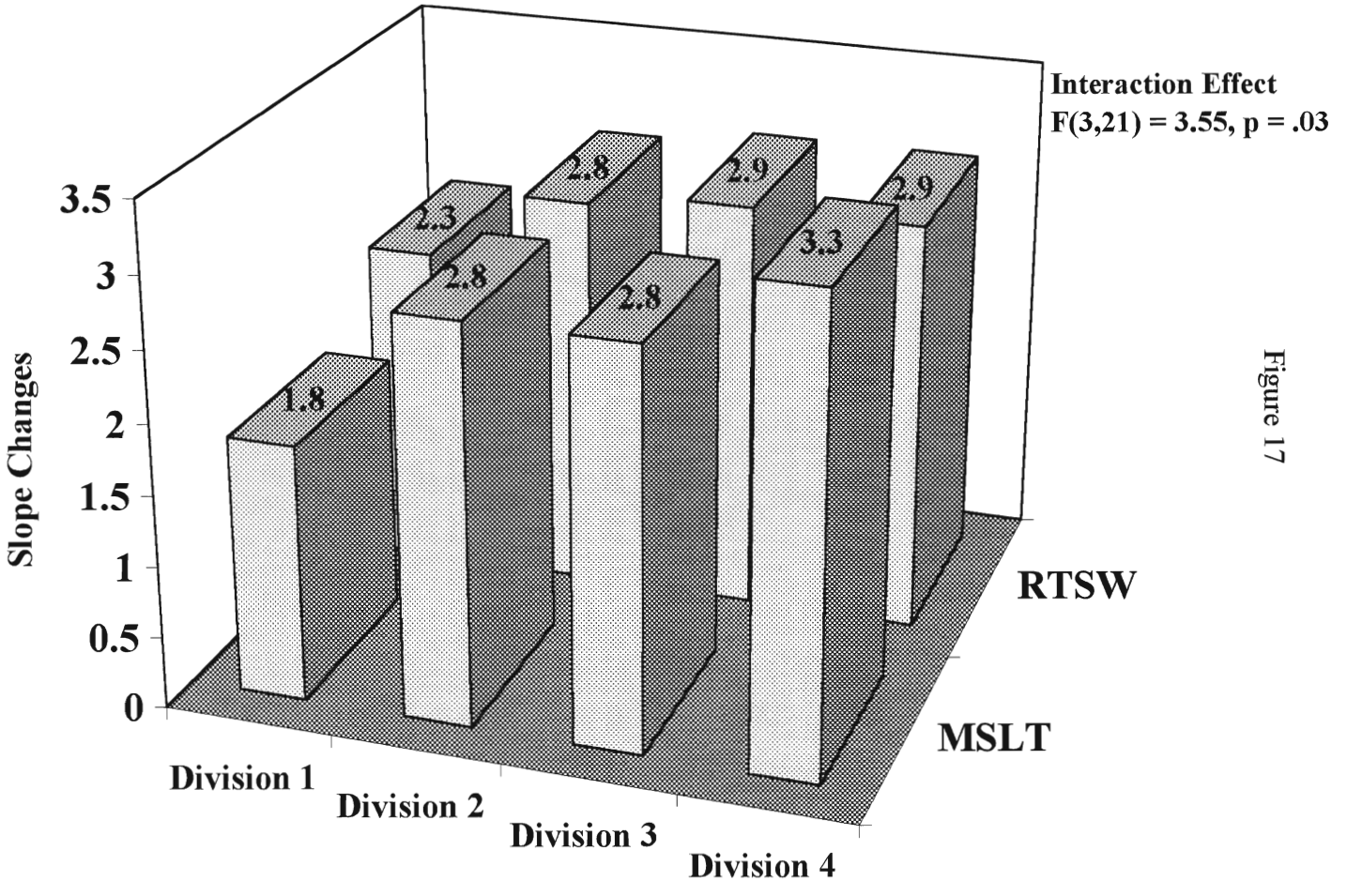


Figure 17

Slope Changes in Beta Power (last 52 epochs)

The number of slope changes in Beta power increased as sleep approached (F (3,21) = 3.5, p = .03, η^2 = .073). Also, there were more slope changes in the earlier testing sessions (F (1,7) = 24.59, p = .002, η^2 = .103)(see table 15 and figure 18). These effects were not detected in the original analysis of the entire sleep onset period. This suggests that perhaps the differences in Beta power variation between the processes of inadvertent and intentional sleep onset may be most evident in the last few minutes of the sleep onset period.

Analysis of EEG Alpha Power (last 52 epochs)

Alpha power dropped across time in general (F (3,21) = 7.84, p = .001, η^2 = .225) (see table 16 and figure 19), but then showed a non-significant increase during the final minute before consolidated Hori stage 9 sleep was reached. This effect was not significant but was consistent across both types of naps. There was also a Nap Type by Division interaction (F (3,21) = 6.84, p = .002, η^2 = .04) (see table 16).

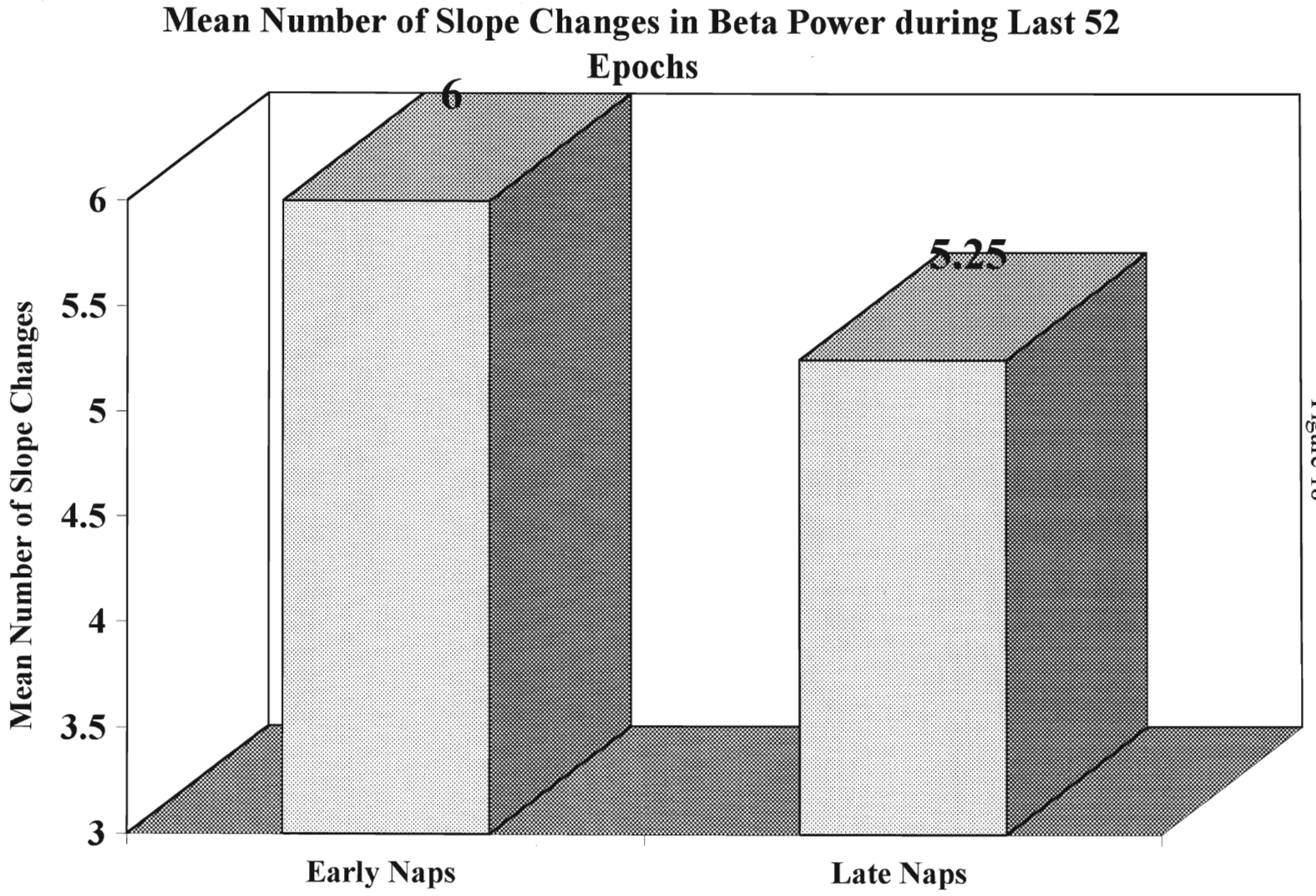
Alpha power during the MSLT was initially higher in Division one (3-4 minutes prior to sleep onset) but then decreased more quickly in the MSLT than it did in the RTSW (see figure 19). This interaction was not present in the analysis of the entire sleep onset period and is contrary to the hypothesis that the expected decrease in Alpha power as sleep approaches would take place later in the RTSW than in the MSLT.

Table 15

Summary ANOVA table for Beta Slope Changes in Last 52 Epochs

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	33.88	4.84				
Nap Type	1	.03	.03	.02	.89		
Within Cells (Nap Type)	7	10.78	1.54				
Time	1	18.00	18.00	24.59	.002		
Within Cells (Time)	7	5.13	.73				
Division	3	25.55	8.52	3.50*	.033	.103	.93
Within Cells (Division)	21	51.08	2.43				
Nap Type X Time	1	.28	.28	.12	.73		
Within Cells (N X T)	7	15.78	2.25				
Nap Type X Division	3	1.92	.64	.51	.68		
Within Cells (N X D)	21	26.52	1.26				
Time X Division	3	.52	.17	.09	.96		
Within Cells (T X D)	21	39.86	1.90				
Nap Type X Time X Division	3	6.64	2.21	3.86*	.024	.026	.95
Within Cells (N X T X D)	21	12.05	.57				
Total	127	247.99					

Note: The following two pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)



F (1,7) = 24.59, p = .002

Figure 18

Table 16

Summary ANOVA table for Alpha Power in Last 52 Epochs

Source	df	SS	MS	F	p	η^2	ϵ
Subjects	7	1.17	.17				
Nap Type	1	.00	.00	.06	.817		
Within Cells (Nap Type)	7	.13	.02				
Time	1	.01	.01	.74	.420		
Within Cells (Time)	7	.13	.02				
Division	3	1.39	.46	7.84*	.001	.225	.408
Within Cells (Division)	21	1.24	.06				
Nap Type X Time	1	.13	.13	3.74	.095		
Within Cells (N X T)	7	.25	.04				
Nap Type X Division	3	.25	.08	6.84*	.002	.040	.675
Within Cells (N X D)	21	.25	.01				
Time X Division	3	.15	.05	1.99	.147		
Within Cells (T X D)	21	.51	.02				
Nap Type X Time X Division	3	.25	.08	5.32*	.007	.040	.405
Within Cells (N X T X D)	21	.33	.02				
Total	127	6.19					

Note: The following three pieces of information are provided for significant results only.
η^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

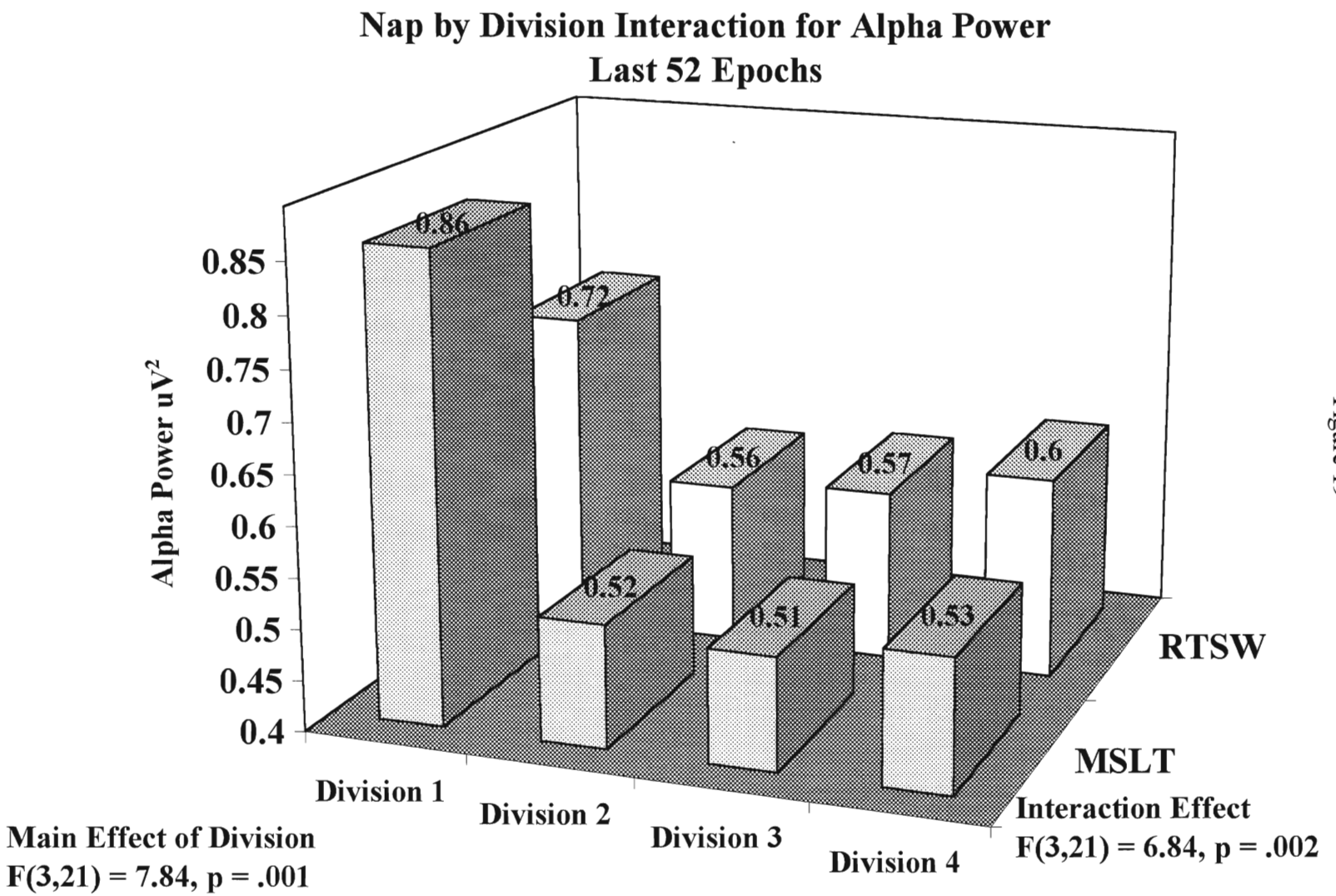

Nap by Division Interaction for Alpha Power
Last 52 Epochs
Alpha Power uV²
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.86
0.72
0.56
0.57
0.6
0.52
0.51
0.53
RTSW
MSLT
Division 1
Division 2
Division 3
Division 4
Main Effect of Division
F(3,21) = 7.84, p = .001
Interaction Effect
F(3,21) = 6.84, p = .002

Figure 19

Analysis of EEG Theta Power (last 52 epochs)

Theta power increased across time for both types of nap tests ($\underline{F}$ (3,21) = 15.9, $\underline{p}$ < .001, η^2 = .276). However, it increased much more rapidly in the MSLT than the RTSW ($\underline{F}$ (3,21) = 3.38, $\underline{p}$ = .04, η^2 = .017) (see table 17 and figure 20). This result was also not present in the initial analyses and also contradicts the interaction hypothesis mentioned above.

Analysis of EEG Beta Power (last 52 epochs)

Beta power was lower later in the night ($\underline{F}$ (1,7) = 17.91, $\underline{p}$ = .004, η^2 = .022) (see figure 21). It was also lower in the later portions of the sleep onset period ($\underline{F}$ (3,21) = 2.72, $\underline{p}$ = .07). However, Beta power only dropped noticeably in the MSLT whereas Beta power in the RTSW remained more stable ($\underline{F}$ (3,21) = 3.42, $\underline{p}$ = .04, η^2 = .015) (see table 18 and figure 22). This lack of a decrease in Beta power is consistent with the interaction hypothesis and provides some evidence that the intention to remain awake persists well into the sleep onset period.

Table 17

Summary ANOVA table for Theta Power in Last 52 Epochs

Source	df	SS	MS	F	p	n^2	ϵ
Subjects	7	12.97	1.85				
Nap Type	1	.67	.67	2.15	.19		
Within Cells (Nap Type)	7	2.18	.31				
Time	1	.09	.09	.20	.67		
Within Cells (Time)	7	3.05	.44				
Division	3	13.74	4.58	15.9**	<.001	.276	.44
Within Cells (Division)	21	6.05	.29				
Nap Type X Time	1	.69	.69	2.69	.14		
Within Cells (N X T)	7	1.79	.26				
Nap Type X Division	3	.83	.28	3.38	.04	.017	.70
Within Cells (N X D)	21	1.73	.08				
Time X Division	3	.35	.12	1.39	.27		
Within Cells (T X D)	21	1.77	.08				
Nap Type X Time X Division	3	.37	.12	.74	.54		
Within Cells (N X T X D)	21	3.53	.17				
Total	127	49.81					

Note: The following two pieces of information are provided for significant results only.
n^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)

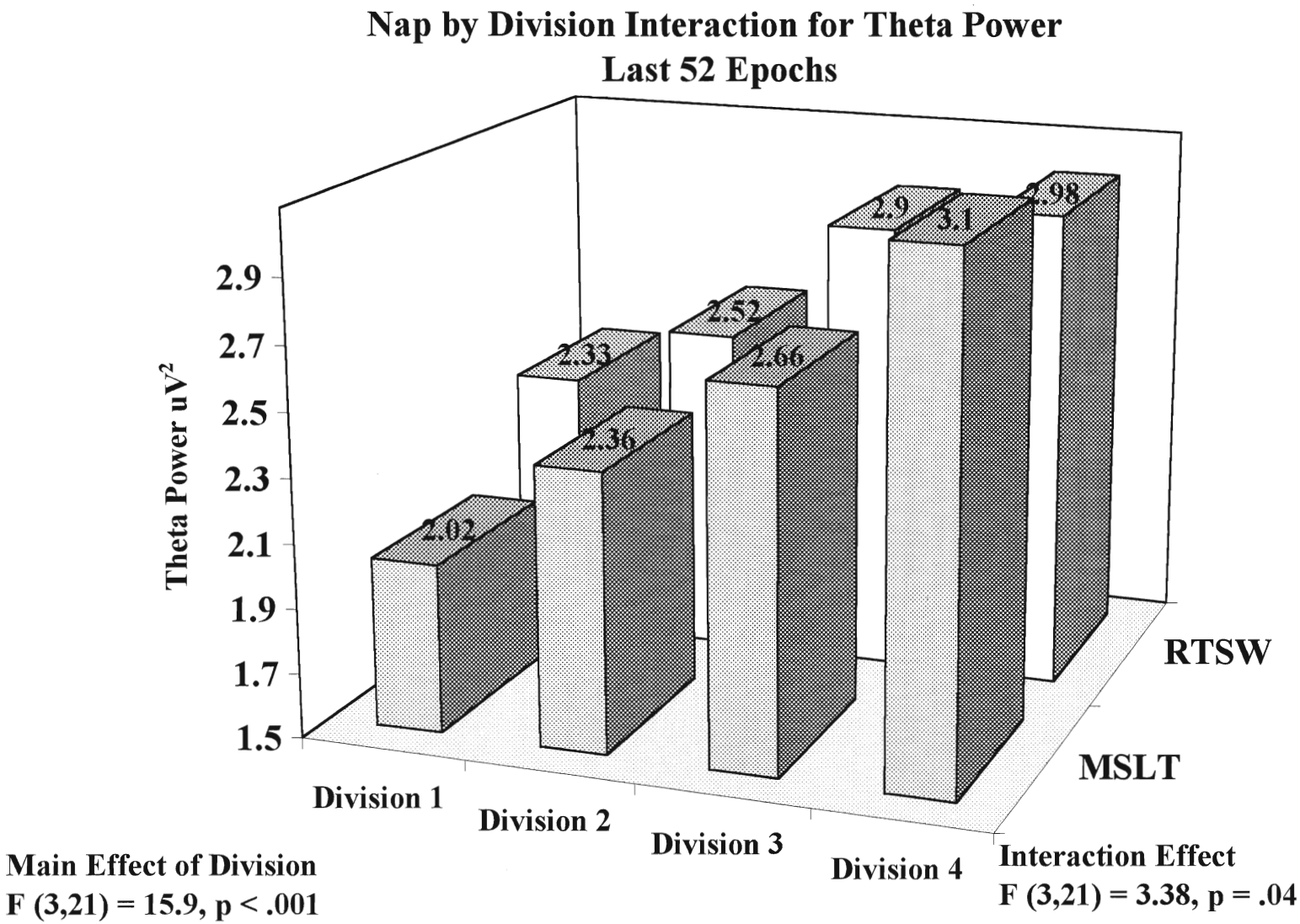
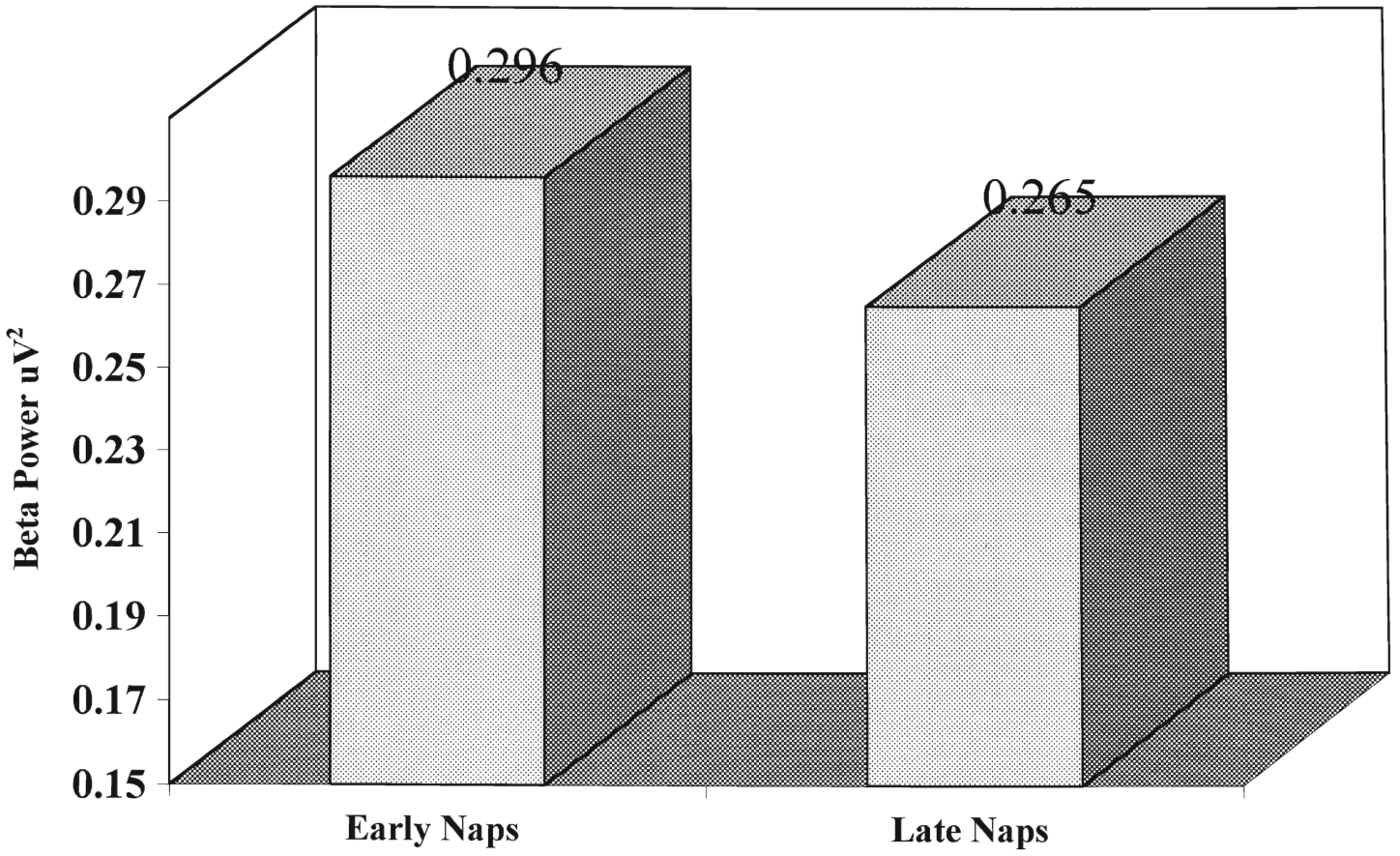

Nap by Division Interaction for Theta Power
Last 52 Epochs
Theta Power uV²
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
2.02
2.36
2.33
2.66
2.52
2.9
3.1
2.98
Division 1
Division 2
Division 3
Division 4
RTSW
MSLT
Main Effect of Division
F (3,21) = 15.9, p < .001
Interaction Effect
F (3,21) = 3.38, p = .04

Figure 20

Mean Beta Power for Early and Late Naps during Last 52 Epochs



F(1,7) = 17.91, p = .004

Figure 21

Table 18

Summary ANOVA table for Beta Power in Last 52 Epochs

Source	df	SS	MS	F	p	n^2	ϵ
Subjects 7	1.04	.15					
Nap Type	1	.00	.00				
Within Cells (Nap Type)	7	.01	.00	1.58	1.58		
Time	1	.03	.03	17.91	.004	.022	
Within Cells (Time)	7	.01	.00				
Division 3	.02	.01	2.72	.07			
Within Cells (Division)	21	.05	.00				
Nap Type X Time	1	.01	.01	2.40	.17		
Within Cells (N X T)	7	.02	.01				
Nap Type X Division	3	.02	.01	3.42	.04	.015	.70
Within Cells (N X D)	21	.04	.00				
Time X Division	3	.01	.00	.56	.65		
Within Cells (T X D)	21	.07	.00				
Nap Type X Time X Division	3	.00	.00	.03	.99		
Within Cells (N X T X D)	21	.03	.00				
Total	127	1.36					

Note: The following two pieces of information are provided for significant results only.
n^2 = eta squared, a measure of the amount of variance accounted for
ϵ = Greenhouse-Geisser epsilon
*p<.05, **p<.01, (after Greenhouse-Geisser correction)
Note: The values of .00 listed above for some Sums of Squares (SS) are NOT true zeros. The actual value is simply less than .005. The program used to calculate this table (SPSSPC+) carries in its working memory 16 decimal places so that even though a two decimal value is listed by default, the actual values are greater than zero and meaningful.

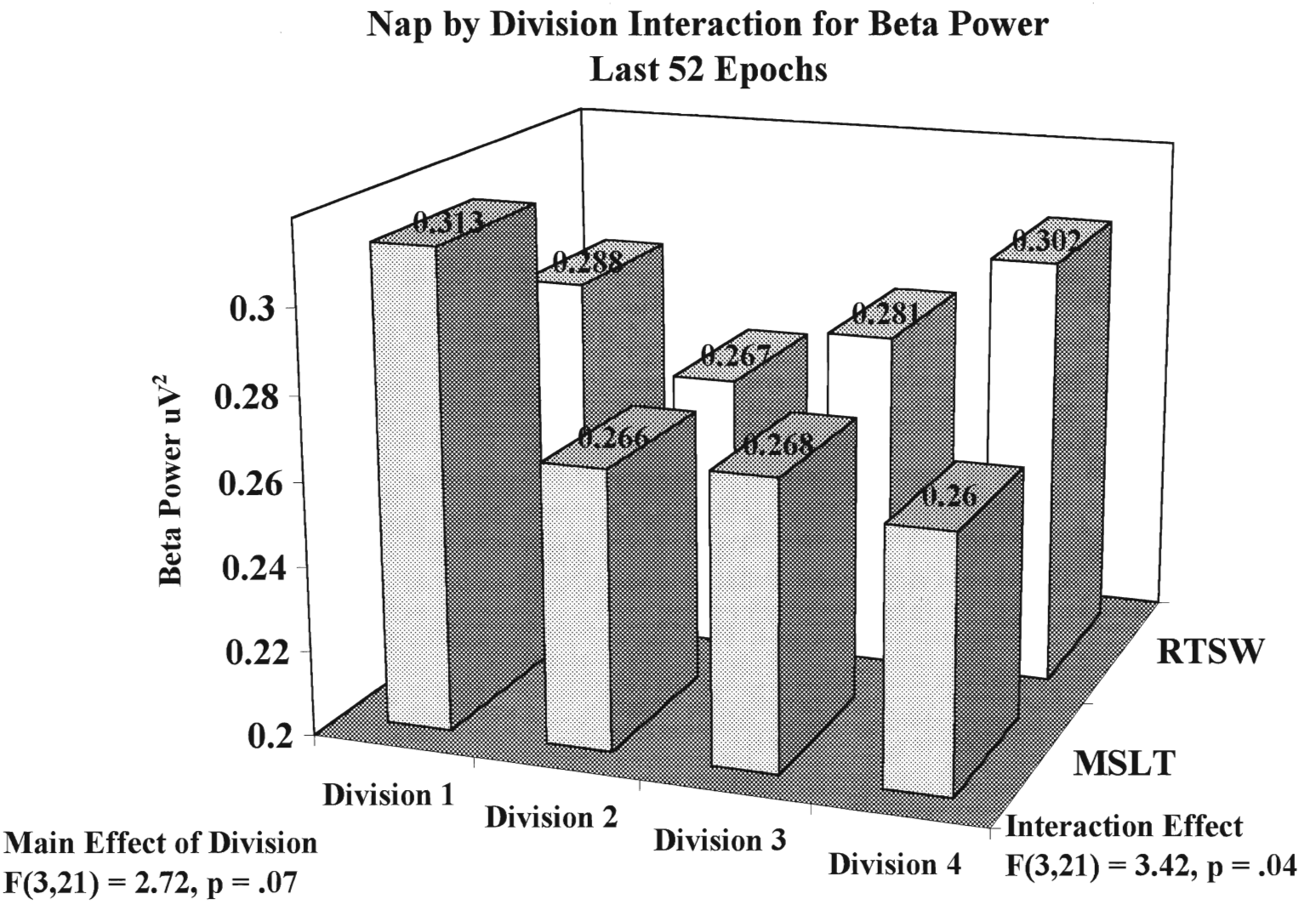

Nap by Division Interaction for Beta Power
Last 52 Epochs
Beta Power uV²
0.3
0.28
0.26
0.24
0.22
0.2
0.313
0.288
0.267
0.281
0.302
0.266
0.268
0.26
Division 1
Division 2
Division 3
Division 4
RTSW
MSLT
Main Effect of Division
F(3,21) = 2.72, p = .07
Interaction Effect
F(3,21) = 3.42, p = .04

Figure 22

Discussion

The main purpose of this study was to examine the effect of intention on the process of falling asleep from an electrophysiological point of view. To test this, two nap conditions, the MSLT and RTSW were used to compare intentional and inadvertent sleep onset. These results will be discussed later. A number of experimental design issues which speak to the validity and reliability of the results will be discussed first.

Control Measures

The counterbalancing in the design of the study appears to have been successful. Subjective (SSS, VASS), objective (AAT), physiological (oral temperature) and a performance measure (RT) of arousal all indicated that there were no significant differences between the two nap conditions. This was an important check to make because of the small sample size. With so few participants providing complete data it was important that these control measures showed no effect to reduce the probability of alternative hypotheses. Also, because there was not a large amount of inherent statistical power due to the small sample size, error variance had to be kept to a minimum.

Demand Characteristics

Another potential problem this study attempted to address was that of demand characteristics. The possibility that participants might find the testing situation sufficiently contradictory that they would be prone to spontaneously create alternate hypotheses as to the actual purpose of the experiment appears to be unfounded. Half of the participants indicated that they were completely convinced of the true purpose of the experiment and none of the 16 original participants indicated any serious questioning of their expected

behaviour. It was therefore assumed that demand characteristics posed little or no threat to the validity of the current investigation.

Effort in the RTSW

Another concern regarding the design of the study was that there may be a differential amount of effort across the two types of nap tests. However, the effort exerted in these two tests also appears to be comparable. There was actually a trend for participants to try harder in the RTSW ($p = .16$), even though they found it harder to perform and did not feel that they did as well on the RTSW as compared to the MSLT.

Usefulness of the Hori Nine Stage Sleep Onset Scoring System

The Hori nine stage scoring system appears to be much more sensitive to subtle changes during the sleep onset period than the traditional scoring methods and shows great promise as a tool for examining the sleep onset period. This system was not difficult to learn and anyone already familiar with standard sleep scoring methods should be able to adapt to the Hori system within a reasonable amount of time.

The Effect of Mental Activity on the Nap Tests

One of the problems with this type of research done in the past (e.g., Hartse et al., 1982) is that there is an implicit assumption that all subjects have comparable mental processes during each test. The MSLT is thought to measure "physiological sleep tendency in the absence of alerting factors" (Carskadon & Dement, 1982). However, the experimenter only controls the external alerting factors (light, temperature, sound).

Internal alerting factors (thoughts and emotions) are more difficult to control so to date they have essentially been ignored. This problem has been pointed out in the past and

suggestions to correct it have been made (Naitoh & Kelly, 1994; Wilkinson, 1992). However, Naitoh and Kelly (1994) and Wilkinson (1992) suggest attempting to control the mental activity of the participants by giving them a secondary task to passively attend to. This would change the structure of the nap tests substantially. For the present investigation I chose to inquire about mental activity after the fact rather than confound or alter the two tests (MSLT & RTSW).

Unfortunately, the small sample size and incomplete questionnaire data did not allow for a thorough evaluation of the hypothesis regarding the participants' mental processes and how they related to the electrophysiological measures. There were some intriguing clues to address this question though. The participants who did completely answer the post-experiment questionnaire indicated, as expected, that their thoughts were more structured during the RTSW and more dreamlike in the MSLT. This difference may have been reflected in the trend towards higher Beta power in the RTSW ($p=.076$). Therefore, although the hypothesis that there was more "dreamlike" mentation in the MSLT and more structured thoughts in the RTSW" was supported to some extent, the related hypothesis that there would be more Alpha and Beta power in the RTSW and more Theta power in the MSLT was not supported in the Alpha and Theta bands, although there was a trend for increased Beta power in the RTSW.

These results must be interpreted with caution because the questionnaire results are based on only 31% of the subjects and the increased Beta power in the RTSW was not significant ($p=.076$).

Sleep Onset Latencies

The hypothesis that the RTSW would produce longer sleep onset latencies was supported. The explicit instructions may have aided in producing this difference. Other research using the RTSW which has not yielded significantly longer sleep onset latencies (e.g., Sugerman & Walsh, 1989) has employed much simpler instructions ("close your eyes but try to remain awake"). This may have contributed to potential demand characteristics or less than maximal effort by the participants in those studies.

The difference in sleep onset latencies in the present study was not as large as expected. In fact, Nap Type only accounts for 2.9% of the variance in the sleep onset latency. Participants took, on average, only 1 minute and 15 seconds longer to fall asleep in the RTSW. One potential reason for these longer latencies which was investigated was that subjects may have exhibited increased movement in the RTSW as a strategy to remain awake. This proved not to be a problem, however, because there was actually a trend towards more movement in the MSLT (10.8% of record) than the RTSW (7.5 %) (see figure 9).

This difference in movement time may be a function of increased concentration to remain awake in the RTSW. If the participant was lying in bed attempting to remain awake, there would be less reason to move or reposition to make herself more comfortable since that would be counter productive for the task at hand. Examination of the post-experiment questionnaire showed that half of the subjects developed strategies to assist them in their effort to remain awake. The strategies listed were cognitive in nature (thought about exams, repeated stay awake in my mind, etc.). Future research in this area

may wish to control for the participants' mental activity by supplying strategies or assigning cognitive tasks. Another alternative would be to expand the post-experiment questionnaires to address these issues in more detail.

There are some other interesting issues to be raised here regarding the increased sleep onset latencies. Are these only marginally increased sleep onset latencies due to insufficient effort by the participants? This may have been the case despite the fact that there was no difference reported in the effort exerted between the two nap tests. It may also be that the participants were implicitly judging the effort they exerted on the two tests differently because the instructions were to "***allow*** yourself to fall asleep" in the MSLT but "***try*** to stay awake" in the RTSW. This discrepancy (one type of test having effort explicitly mentioned in the instructions and the other instructions being more passive) may have altered how the participants answered the questions regarding effort.

It is quite likely that the relatively small difference in sleep onset latencies was observed because the physiological tendency to enter sleep when tired is sufficiently powerful that under these sleep-promoting conditions the intention to remain awake, without the opportunity to alter one's environment or arouse oneself in other ways, is simply too great for large differences in sleep onset latencies to be observed.

Another explanation for the small differences in latencies (and perhaps the non-significant results in other studies) involves the arousing experience of taking part in an experiment. Evidence has existed for some time that people suffering from insomnia may also be more physiologically aroused (Monroe, 1967). Perhaps this increased arousal due to the novelty of the testing situation creates a temporary, laboratory induced form of

insomnia. In other situations this would be recognized as the First Night Effect (FNE) (Browman & Cartwright, 1980). Working under the assumption that the FNE acts like an artificial insomnia it would follow that therapies designed to alleviate sleep onset insomnia may also be effective in reducing the FNE.

One behavioural therapy used with sleep onset insomniacs is paradoxical intention (Ascher, & Efran, 1978; Fogle & Dyal, 1983). To describe it as briefly as possible, insomniacs are instructed to go to bed but "*try to remain awake*" (Ascher & Efran, 1978). This counter intuitive therapy has been reported to reduce sleep onset latency in insomniacs (Ascher & Efran, 1978). To bring this full circle, do paradigms like the one in the present study unintentionally "create" insomnia by placing participants in an arousing situation and then "cure" it with paradoxical instructions? There are no data in the present study to address this idea, but if this idea does have any merit, it raises some interesting methodological problems for the design of future studies which plan to use nap tests like the RTSW.

Sleep Trajectories for the Entire Sleep Onset Period

The hypothesis that the sleep trajectory in the RTSW would be more ragged than in the MSLT was supported for the Hori sleep scoring analysis. As with the latency data, this effect was small accounting for only 3.2% of the variance. Figures 23 to 26 show the sleep onset period of a representative participant in each of the four main conditions (2 MSLTs early and late, and 2 RTSWs, early and late). Notice the generally smoother trajectory in the MSLT in both the early and late naps as compared to the RTSW.

The slope change data for the power spectral analysis showed no significant

differences between the naps for Alpha, Theta or Beta. However, given the ability of the Hori scoring system to differentiate between the two types of sleep onset, it seems unlikely that the trajectories of intentional and inadvertent sleep onset as expressed by slope changes in power would not differ from each other. There are at least two possible explanations why the slope changes in the power spectral analysis failed to find a difference between the trajectories of intentional and inadvertent sleep onset.

The first is that there was not sufficient power in this design to show an effect with only 8 subjects. This possibility cannot be excluded but appears to be an unlikely candidate for an alternative hypothesis. The magnitude of the observed non-significant differences in the average number of Beta and Theta slope changes is too small for anything except a very large study to demonstrate any effects. The slope changes in the Alpha band are more promising but even here the differences are too small to be thought of as more than a trend ($p=.17$).

Another more likely possibility is that the jitter factor in the Arouse program was set too high to produce a useful number of slope changes reliably. Recall that the jitter factor was set at 50% (.5 of one standard deviation). This was chosen a priori to exclude the 40% of smallest slope changes but in retrospect this may also have eliminated too much meaningful data. Future research using this type of program should experiment further with different jitter factors to determine an optimum percentage of the overall standard deviation which produces meaningful results.

It was also hypothesized that there would be an interaction between the Nap Type and the number of slope changes per Division for Alpha, Theta and Beta such that the

expected rise in Theta and fall in Beta and Alpha would not occur until later in the sleep onset process in the RTSW. The interaction was present only for the Theta band; however, it was in the opposite direction to that which was expected. The number of slope changes in Theta power rose more quickly in the RTSW through the middle of the record (2nd and 3rd divisions) but was lower just prior to sleep onset (4th quartile) (see figure 12). However, the levelling off of the increases in Theta in the latest stages of the sleep onset period would be consistent with an effort to resist sleep.

Santamaria and Chiappa (1987) describe Theta bursts which they observed in "drowsy" participants. Perhaps then the unexpected result of increased Theta slope changes in the MSLT was a result of these naturally occurring Theta bursts. These Theta bursts could result in an increased number of slope changes in the EEG during an unopposed sleep onset (MSLT). Conversely, the lower number of Theta slope changes in the RTSW could possibly be an indication that these Theta bursts are being suppressed by the effort to remain awake. This possibility merits further inquiry.

There was a significant difference in the number of Hori sleep stage changes between the two types of naps in support of the hypothesis that inadvertent sleep onset would follow a more ragged trajectory. There were, on average, more stage (slope) changes in the RTSW than in the MSLT. Examples of the actual pattern of Hori stage changes and power in the Theta and Alpha bands can be seen in figures 23 to 26 on the following pages. Thus, the nine stage Hori system for scoring the sleep onset period appears to be sensitive to the altered physiological patterns associated with the intention to remain awake.

Hori et al. (1994) have already shown that this nine stage scoring system is linearly related to both reaction time and the subjective assessment of the likelihood one has been asleep. Further analysis and development of this scoring system certainly seems warranted. This system should allow researchers to examine the sleep onset period with much more clarity in the future.

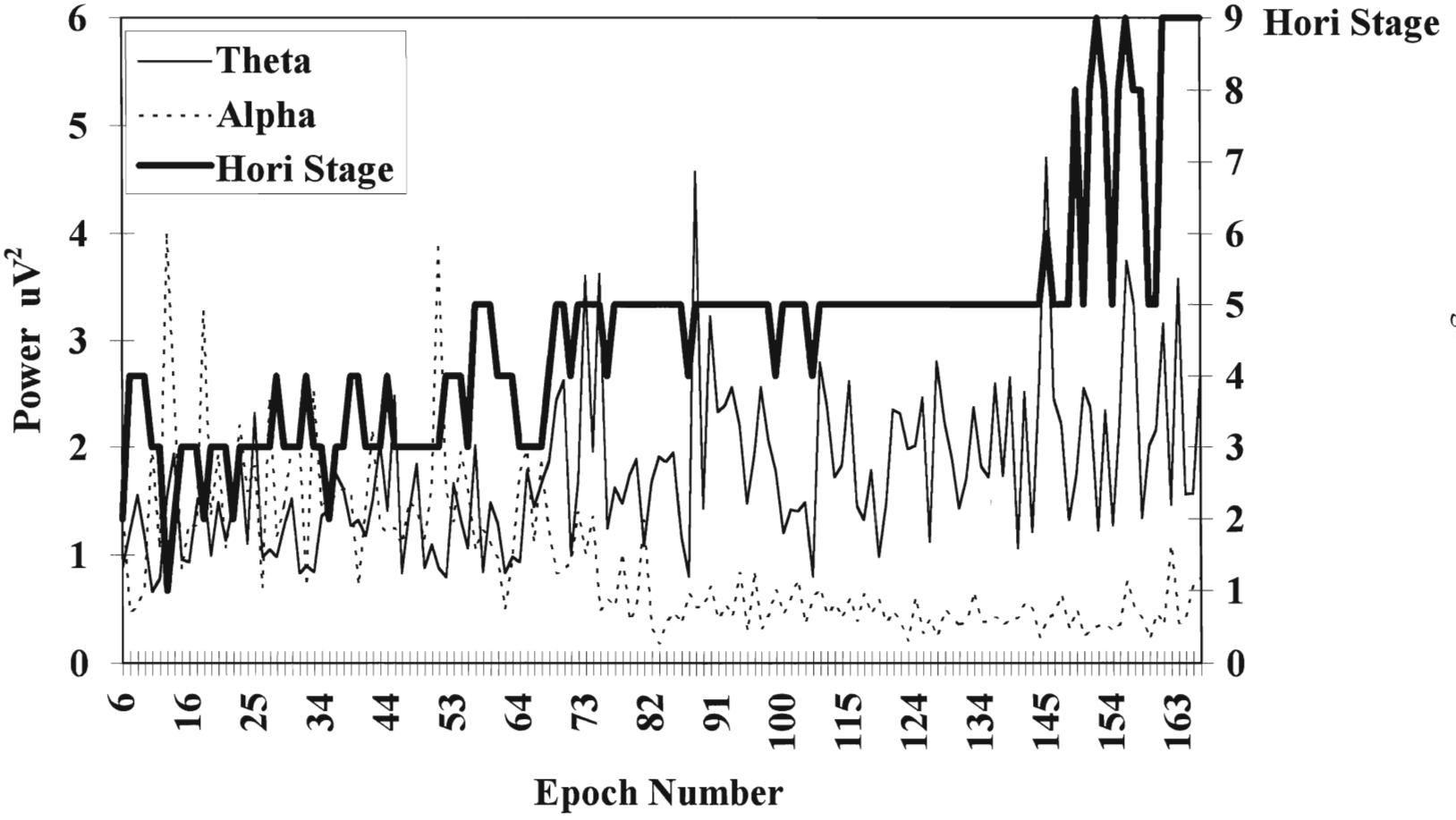
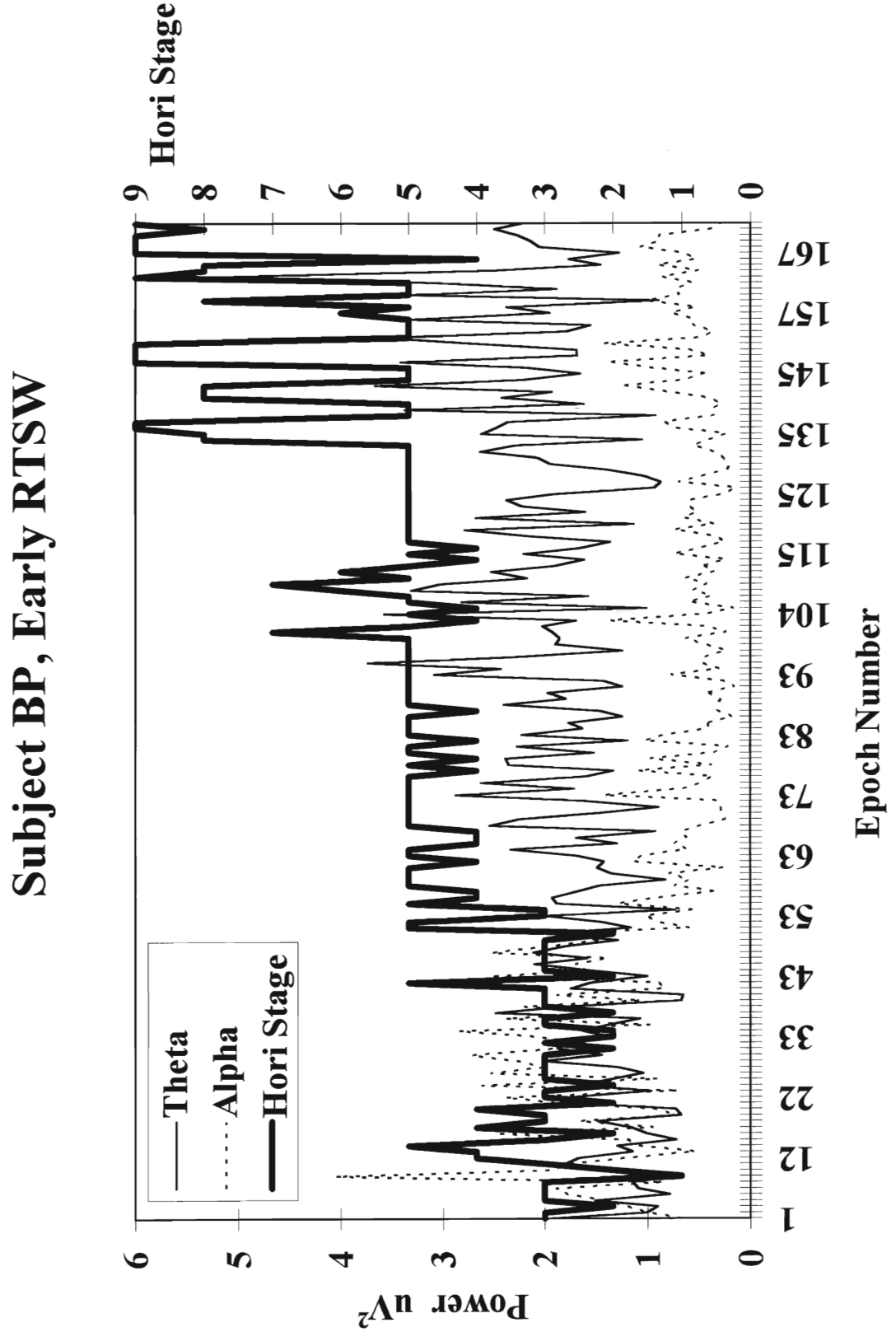

Subject BP, Early MSLT
Theta
Alpha
Hori Stage
Power uV2
Hori Stage
Epoch Number
0
1
2
3
4
5
6
7
8
9
6
16
25
34
44
53
64
73
82
91
100
115
124
134
145
154
163

Figure 23

Figure 24


Subject BP, Early RTSW
Theta
Alpha
Hori Stage
Power uV²
Hori Stage
Epoch Number
0
1
2
3
4
5
6
7
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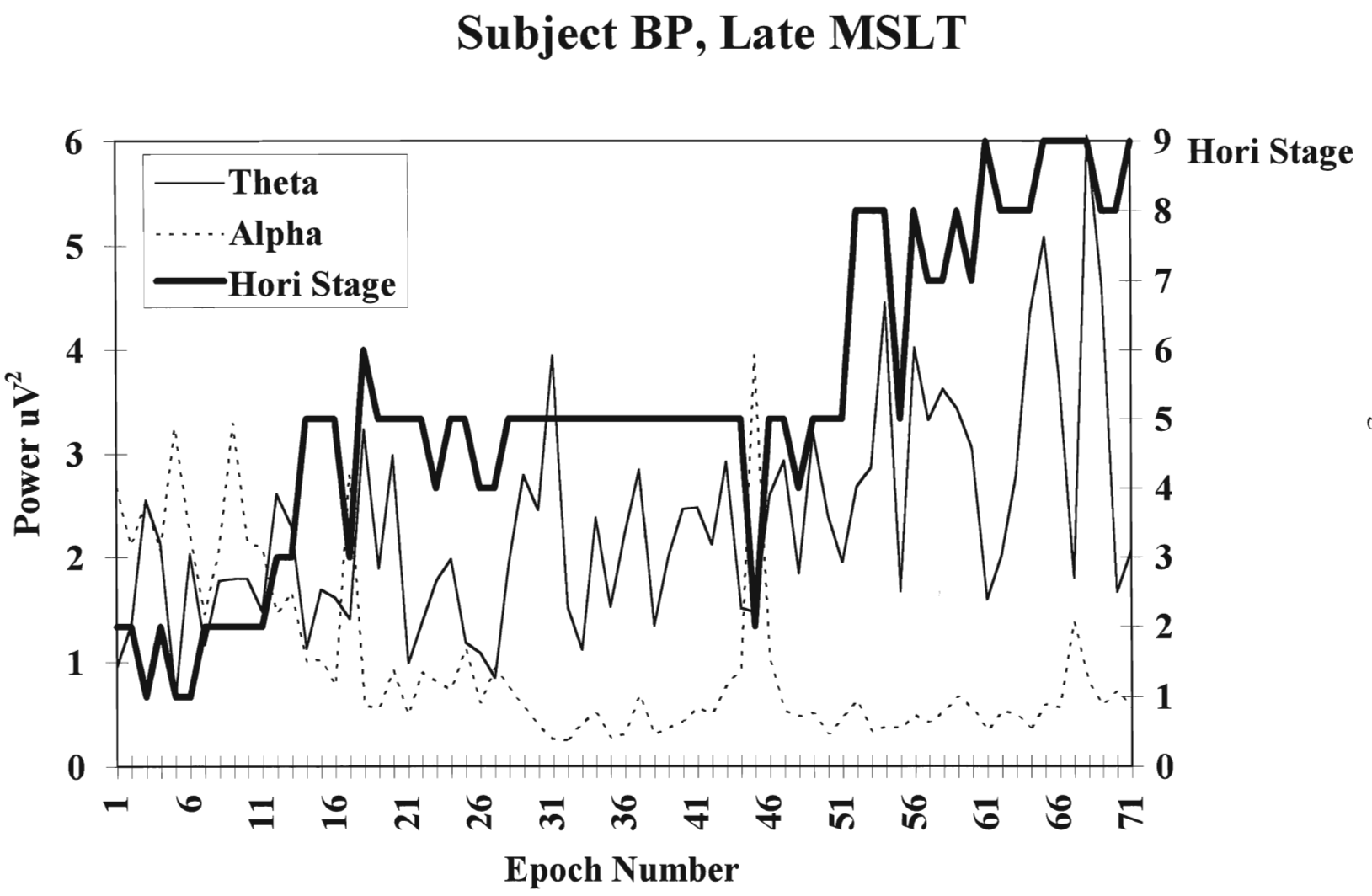
Subject BP, Late MSLT
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Figure 25

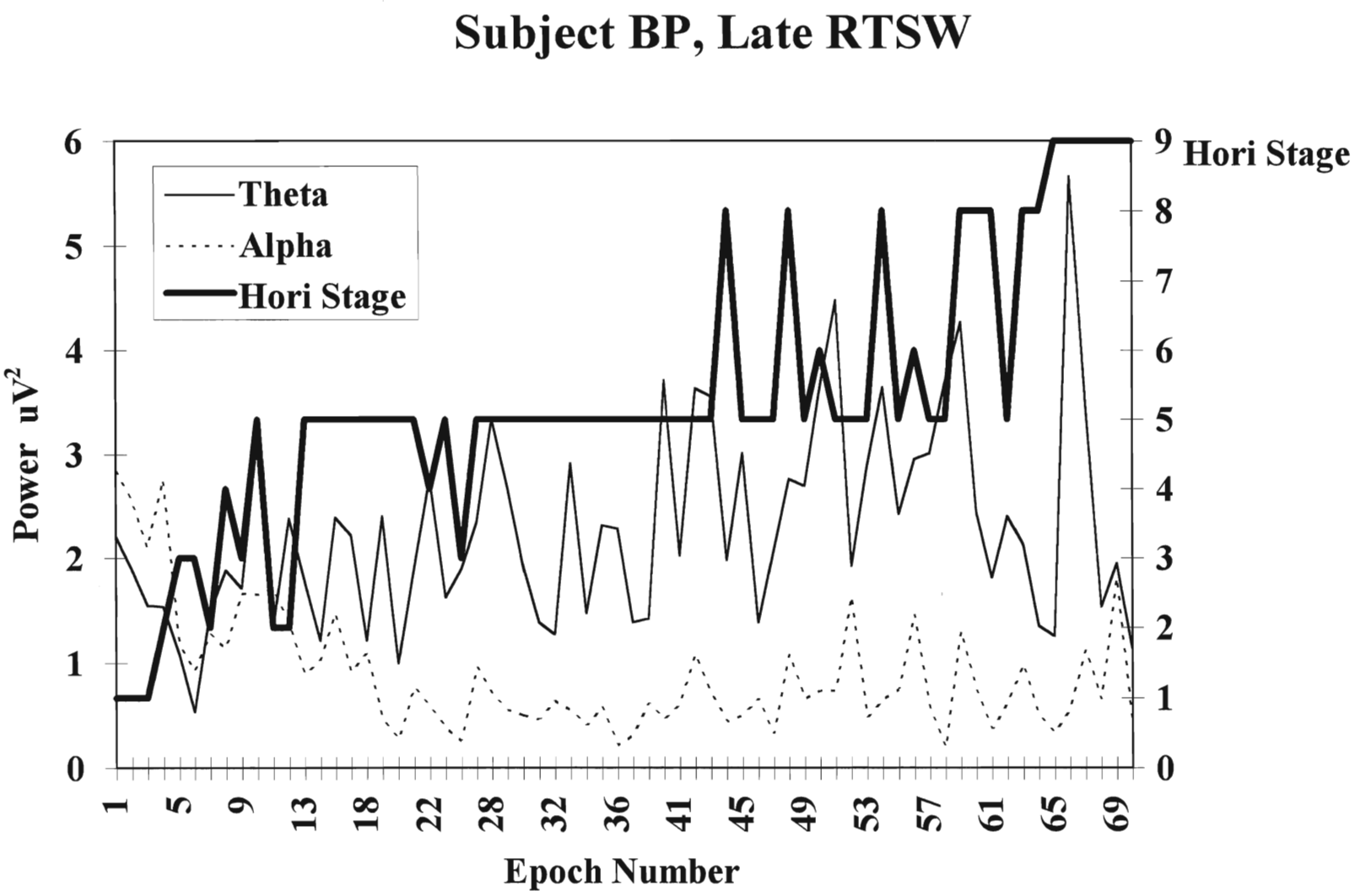
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Figure 26

Analysis of the Last 52 Epochs of each Record

Analyses were undertaken to determine if there would be differences in the sleep onset period up to initial stage 2 (Rechtschaffen & Kales, 1968) sleep. Working backwards from the point at which Hori stage 9 (Rechtschaffen & Kales stage 2) sleep was consolidated (4 of 6 epochs stage 9), the final 52 epochs of each record were subjected to the same analyses as the original data.

As in the analysis of the entire sleep onset record, there were significantly more Hori stage changes in the RTSW than in the MSLT (see figure 15) whereas slope changes in Alpha, Theta and Beta all failed to demonstrate any main effects for nap. There were significantly more slope (stage) changes in the RTSW than in the MLST. Again this is an indication of the increased sensitivity of the Hori system although the size of the effect remains small (3.6% of the variance). This system appears to be more powerful than conventional scoring systems or power spectral analysis at quantifying the trajectory into sleep during the sleep onset period.

One very interesting finding was that during the last 52 epochs before sleep onset, there were Nap Type by Division interactions for Alpha, Theta and Beta using power data. Just prior to sleep onset (the last one minute) there was a slight increase in Beta power in the RTSW while Beta power continued to drop in the MSLT (see figure 22). Theta power also increased in the final minute in both naps but less so in the RTSW compared to the MSLT (see figure 20). Alpha power was initially higher in the MSLT but dropped quickly to levels below that of the RTSW (see figure 19). These interactions are all occurring simultaneously with the expected main effects for each power band. In general,

Alpha and Beta power are decreasing during this time and Theta power is increasing.

When compared to the analysis of the entire sleep onset period, it is clear that the most reliable changes in the electrophysiological data occur late in the sleep onset period just prior to (and possibly including) the time when Hori stage 9 (conventional stage 2) sleep begins. These observed differences in the final minute before sleep onset lend support to the notion that the intention to remain awake continues to affect the EEG of a person, at least up to the point where Hori stage 9 (Rechtschaffen & Kales stage 2) sleep is reached.

However, these differences late in the sleep onset period did not all follow the hypothesized pattern. Only Beta power followed the originally hypothesized pattern of remaining higher in the RTSW until late in the sleep onset period.

During the last 52 epochs, Alpha power was initially higher in the MSLT before dropping to marginally lower levels in the final 3 Divisions (last 3 minutes) before sleep onset. This higher Alpha power would appear to indicate that participants were more highly aroused in the MSLT than in the RTSW during this Division (3-4 minutes before sleep onset).

Size of Effects Attributable to Intention

As predicted, increased sleep onset latencies were observed for those naps in which the participant was instructed to remain awake. There was also support for the hypothesized increased raggedness of the sleep trajectory as indicated by increased stage changes using the Hori scoring system. Evidence for an effect of intention which persists at least until sleep onset is essentially complete was also demonstrated. However, only

Beta displayed the expected pattern of delayed changes in the RTSW while the Alpha and Theta patterns were contradictory to the hypotheses.

All of these effects, although statistically significant, were quite small. The largest effect which involved Nap Type as a main effect (Hori stage changes) only accounted for 3.2 % of the variance. Also, only 2.9% of the variance in sleep onset latency could be explained by Nap Type. The largest effect involving Nap Type within an interaction was for the Nap Type by Time interaction for Alpha slope changes in the last 52 epochs. This interaction accounted for 4.1% of the variance.

Therefore, the effect of intention, while measurable, does not appear to reflect large changes in the sleep onset latency or process. Perhaps the effect of intention when isolated in a paradigm such as was used in the present study is, in fact, quite small.

In a more natural setting (perhaps in a life threatening situation such as operating a motor vehicle while drowsy), the goal of remaining awake would result in much more than simply the intention to remain awake. People will employ various strategies to maintain their arousal. These strategies typically involve a manipulation of the environment such as turning on lights, moving, ingesting stimulants etc. Therefore, the effect of intention would manifest itself in a variety of activities to assist the person in their effort to resist sleep.

Size of Effects Attributable to the Sleep Onset Process

In sharp contrast to the magnitude of the effects attributable to intention, the effects associated with the onset of sleep are very large. The Division factor, a measure of the change in the various parameters over the sleep onset period accounts for up to 59%

of the variance in the same variables for which intention (Nap Type) accounted for less than 5%. This difference indicates how powerful the inclination to sleep is when compared to the intention to remain awake under sleep-promoting conditions.

Summary of data as they related to Hypotheses

All four hypotheses received varying degrees of support from the data. However, only the first (increased latencies) and the fourth (more structured thoughts in the RTSW) were unambiguously supported. Support for the second (increased slope changes) and third (delay of sleep onset characteristics in RTSW) hypotheses was more equivocal. Increased slope changes in the RTSW were only observed for Hori sleep scoring. There may be quantifiable differences between inadvertent and intentional sleep onset which the Arouse program did not report due to the jitter factor being set too high. The most reliable effect was that of Nap Type by Division interactions observed in Alpha, Theta and Beta power during the last 52 epochs prior to sleep onset. However, of these interactions, only Beta was in an expected pattern.

The consistent Nap Type by Division interactions shown in the analysis of the last 52 epochs can be interpreted two ways. It may be that the most reliable changes occur just prior to sleep onset. A second alternative explanation is that by selecting a stable internal biological marker (the first appearance of sleep spindles) and counting backwards from that marker you can eliminate some of the error variance which you encounter when analysing forward from the external marker of "lights out". As Naitoh and Kelly (1994) point out, the MSLT *assumes* that each subject has comparable thought processes during each test. However, there is no way of determining if each participant is comparably

relaxed and comfortable at the "lights out" point.

Applications

The results of this study have some potentially serious implications for people who are required to remain awake but are unable to engage in typical sleep resisting (arousing) behaviour. If the intention to remain awake alone is not sufficient to drastically alter the onset of sleep, then a worker who is confined by the nature of his/her job (e.g., Air Traffic Controller) and is unable to alter his/her environment would be much more susceptible to inadvertent sleep onset.

Future Research

The present study placed participants in an unnatural situation in order to isolate the effect of intention alone. Future research in this area should vary the amount of stimulation a participant receives and monitor this effect on the sleep onset period. Variations in body position, temperature, lighting, noise should all be investigated to determine their effect on intentional and inadvertent sleep onset.

Conclusions

The present study set out to quantify and describe the differences in the processes of intentional and inadvertent sleep onset. Previous research has shown that longer sleep onset latencies can be produced by the intention to remain awake (Hartse et al., 1982). However, these increased latencies are not always observed (Sugerman & Walsh, 1989). By employing explicit instructions the current investigation did produce longer sleep onset latencies in the RTSW.

Furthermore, the processes involved in intentional and inadvertent sleep onset were examined through the use of power spectral analysis and a new sleep onset scoring system. This allowed for a more detailed analysis of both intentional and inadvertent sleep onset processes than had been attempted in the past.

It now appears that these processes differ at least up until the point where consolidated sleep is thought to occur (Rechtschaffen & Kales stage 2). This would indicate that natural processes associated with sleep onset can be influenced by volition at least until a person is essentially asleep.

However, the effect of intention, although quantifiable and reliable, is relatively small. Therefore these data do not suggest that a person would be adequately attentive throughout the sleep onset process to perform a task reliably. This aspect of inadvertent sleep onset (how long a person is adequately attentive) will require further evaluation at some point in the future.

References

Akerstedt, T. (1991) Sleepiness at work: Effects of irregular work hours. In T. H. Monk (Ed.) Sleep, Sleepiness and Performance. (pp. 129-154) Chichester:Wiley.

Akerstedt, T., & Folkard, S. (1994) Prediction of intentional and unintentional sleep onset. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 73-88). Washington: American Psychological Association.

Akerstedt, T., & Gillberg, M. (1990) Subjective and objective sleepiness in the active individual. International Journal of Neuroscience, 52, 29-37.

Alloway, C. E. D., Ogilvie, R. D., & Shapiro, C. M. (1995). The alpha attenuation test: Assessing physiological sleepiness in narcolepsy. Sleep Research, 24, 187.

Anch, A. M., Browman, C. P., Mitler, M. M., & Walsh, J. K. (1988). Sleep: A scientific Perspective. Englewood Cliffs: Prentice-Hall.

Armitage, R., Hudson, A., Fitch, T., & Pechacek, P. (1994). In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 185-200). Washington: American Psychological Association.

Ascher, L. M., & Efran, J. S. (1978). Use of paradoxical intention in a behavioral; program for sleep onset insomnia. Journal of Consulting and Clinical Psychology, 46, 547-550.

Badia, P., Wright, K. P.,& Wauquier, A. (1994). Fluctuations in single hertz activity during the transition to sleep. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 201-218). Washington: American Psychological Association.

Broughton, R. (1994) Important underemphasized aspects of sleep onset. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 19-35). Washington: American Psychological Association.

Browman, C. P., & Cartwright, R. D. (1980). The first-night effect on sleep and dreams. Biological Psychiatry, 15, 809-812.

Carskadon, M., & Dement, W. (1982) The multiple sleep latency test: What does it measure? Sleep, 5(supp), S67-S72.

Coburn, K. L., & Moreno, M. A. (1988). Facts and artifacts in brain electrical activity mapping. Brain Topography, 1, 37-45.

Cohen, J., & Cohen, P. (1983). Applied multiple regression/correlation analysis for the behavioral sciences. Hillsdale, NJ: Erlbaum.

Daan, S., Beersma, D., & Borbely, A. (1984). Timing of human sleep: Recovery process gated by a circadian pacemaker. American Journal of Physiology, 246, R161-R178.

Davis, H., Davis, P. A., Loomis, A. L., Harvey, E. N., & Hobart, G. (1937). Changes in human brain potentials during the onset of sleep. Science, 86, 448-450.

Davis, H., Davis, P. A., Loomis, A. L., Harvey, E. N., & Hobart, G. (1938). Human brain potentials during the onset of sleep. Journal of Neurophysiology, 1, 24-38.

Dement, W. C., & Kleitman, N. (1957). The relation of eye movements during sleep to dream activity: An objective method for the study of dreaming. Journal of Experimental Psychology, 53, 339-346.

Erman, M., Beckman, B., Gardner, D., & Roffwarg, H. (1987) The modified assessment of sleepiness test (MAST) Sleep Research, 16, 550.

Folkard, S., & Akerstedt, T. (1991) A three process model of the regulation of alertness and sleep. In R. Broughton & R. Ogilvie (Eds.) Sleep, Arousal and Performance. (pp. 11-26). Cambridge: Birkhauser.

Fogle, D. O., & Dyal, J. A. (1983). Paradoxical giving up and the reduction of sleep performance anxiety in chronic insomniacs. Psychotherapy: Theory, Research and Practice, 20, 21-30.

Folstein, M., & Luria, R. (1973) Reliability, validity, and clinical application of the visual analogue mood scale. Psychological Medicine, 3, 479-486.

Hartse, K., Roth, T., & Zorick, F. (1982) Daytime sleepiness and daytime wakefulness: The effect of instruction. Sleep, 5(supp), S107-S118.

Hasan, J., & Broughton, R. (1994). Quantitative topographic EEG mapping during the transition to sleep. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 219-235). Washington: American Psychological Association.

Heitmann, A., Stampi, C., Anandan, S. (1995). The alpha attenuation test: Its first application for objective assessment of sleepiness in field studies. Sleep Research, 24, 100.

Hoddes, E., Zarcone, V., Smythe, H., Phillips, R., & Dement, W. (1973) Quantification of sleepiness: A new approach. Psychophysiology, 10, 431-436.

Hori, T. (1985). Spatiotemporal changes of EEG activity during waking-sleeping transition period. International Journal of Neuroscience, 27, 101-114.

Hori, T., Hayashi, M., & Morikawa, T. (1994). Topographical EEG changes and the hypnagogic experience. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 237-254). Washington: American Psychological Association.

Horne, J., & Ostenberg, O. (1976) A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. International Journal of Chronobiology, 4, 97-110.

James, W. (1890). Principles of psychology. New York: Holt.

Jasper, H. H. (1958). The ten twenty electrode system of the international federation. Electroencephalography and Clinical Neurophysiology, 10, 371-375.

Kleitman, N. (1963). Sleep and Wakefulness rev ed. Chicago: University of Chicago Press.

Ladd, G. T. (1887). Elements of physiological psychology. New York: Scribners.

Lamarche, C., & Ogilvie, R. D. (1995). EEG during the sleep onset period on two groups of insomniacs. Sleep Research, 24, 271.

Leger, D. (1994). The cost of sleep related accidents: A report for the national commission on sleep disorders research. Sleep, 17, 84-93.

Loomis, A. L., Harvey, E., & Hobart, G. A. (1937). Cerebral states during sleep, as studied by human brain potentials. Journal of Experimental Psychology, 21, 127-144.

McCartt, A. T., Pack, A. M., Walsleben, J. A., Hammer, M. C., & Pack, A. I. (1995). Scope of the problem of sleepiness and vehicular crashes: A population survey approach. Sleep Research, 24, 449.

Michimori, A., Stampi, C., & Stone (1993) Relationship between the alpha attenuation test and performance assessment battery. Sleep Research, 22, 374.

Michimori, A., Stone P., Aguirre, A., & Stampi, C. (1994,) Analysis of the alpha attenuation test. Sleep Research, 23, 454.

Mitler, M., Gujavarty, S., & Browman, C. (1982) Maintenance of wakefulness test: A polysomnographic technique for evaluating treatment efficacy in patients with excessive somnolence. Electroencephalography and Clinical Neurophysiology, 53, 658-661.

Monroe, L. J. (1967). Psychological and physiological differences between good and poor sleepers. Journal of Abnormal Psychology, 72, 255-264.

Naitoh, P., & Kelly, T. L. (1994) Modification of the Multiple Sleep Latency Test. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 327-338). Washington: American Psychological Association.

Ogilvie, R. D., & Harsh J. R. (1994) Sleep onset: Normal and abnormal processes. Washington: American Psychological Association.

Ogilvie, R. D., Simons, I. A., Kuderian, R. H., MacDonald, T., & Rustenburg, J. (1991). Behavioral, event-related potential, and EEG/FFT changes at sleep onset. Psychophysiology, 28, 54-64.

Ogilvie, R. D., & Wilkinson, R. T. (1984) The detection of sleep onset: Behavioural and physiological convergence. Psychophysiology, 21, 510-520.

Ogilvie, R. D., & Wilkinson, R. T. (1988) Behavioural versus EEG-based monitoring of all night sleep wake patterns. Sleep, 11, 139-155.

Ogilvie, R. D., Wilkinson, R. T., & Allison, S. (1989) The detection of sleep onset: Behavioural, physiological, and subjective convergence. Sleep, 12, 458-474.

Pack, A. M., Cucchiara, A., Schwab, W., Rodgman, E, & Pack, A. I. (1994) Characteristics of accidents attributed to the driver having fallen asleep. Sleep Research, 23, 141.

Pack, A. M., Willis, D. K., & Pack, A. I. (1995). Variation in methods used by state police to identify a crash as being caused by a driver falling asleep at the wheel. Sleep Research, 24, 452.

Patrick, G. T., & Gilbert, J. A. (1896). On the effects of loss of sleep. Psychological Review, 3, 469-483.

Pivik, R. T. (1991). The several qualities of sleepiness: Psychophysiological considerations. In T. H. Monk (Ed.) Sleep, Sleepiness and Performance. Chichester:Wiley (pp. 3-38).

Rechtschaffen, A. (1994) Sleep onset: Conceptual issues. In R. D. Ogilvie and J. R. Harsh (Eds.) Sleep onset: Normal and Abnormal Processes. (pp. 185-200). Washington: American Psychological Association.

Rechtschaffen, A., & Kales, A. eds. (1968) A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. NIH publication no. 204. Bethesda, MD: National Institute on Neurological Disease and Blindness.

Richardson, G., Carskadon, M., Flagg, M., Van Den Hoed, W., Dement, W., & Mitler, M. (1978) Excessive daytime sleepiness in man: Multiple sleep latency measurement in narcoleptic and control subjects. Electroencephalography and Clinical Neurophysiology, 45, 621-627.

Rose, M., Ware, C., Wooten, V, & Bond, T. (1995). Anxiety and MSLT scores. Sleep Research, 24, 126.

Roth, P. (1994). Missing data: A conceptual review for applied psychologists. Personnel Psychology, 47, 537-558.

Santamaria, J., & Chiappa, K. H. (1987). The EEG of drowsiness. New York: Demos.

Stampi, C., Michimori, A., & Aguirre, A. (1995) Comparison between three versions of the alpha attenuation test for the objective assessment of sleepiness. Sleep Research, 24, 499.

Stampi, C., Stone P., & Michimori, A. (1993) The alpha attenuation test: A new quantitative method for assessing sleepiness and its relationship to the MSLT. Sleep Research, 22, 115.

Sugerman, J., & Walsh, J. (1989) Physiological sleep tendency and ability to maintain alertness at night. Sleep, 12, 106-112.

Thorpy, M. (1992) The clinical use of the multiple sleep latency test. Sleep, 15, 268-276.

Timms, R. M., Shaforenko, R., Hajdukovic, R. M., & Mitler, M. M. (1985). Sleep apnea syndrome: Quantitative studies of nighttime measures and daytime alertness. Sleep Research, 14, 222

Townsend, R. & Johnson, L. C. (1979). Relation of frequency-analyzed EEG to monitoring behaviour. Electroencephalography and Clinical Neurophysiology, 47, 272-279.

Valley, V., & Broughton, R. (1983). The physiological (EEG) nature of drowsiness and its relation to performance deficits in narcoleptics. Electroencephalography and Clinical Neurophysiology, 55, 243-251.

Vasey, M. W. & Thayer, J. F. (1987). The continuing problem of false positives in repeated measures ANOVA in psychophysiology: A multivariate solution. Psychophysiology, 24, 479-486.

Wagner, A. K., Ehrenberg, B. L., Bungay, K. M. & Rodgers, W. H. (1995) The health-related quality of life of people with dyssomnias. Sleep Research, 24, 457.

Webb, W. B. (1994) Prediction of sleep onset. In R. D. Ogilvie and J. R. Harsh (Eds.), Sleep onset: Normal and Abnormal Processes. (pp. 53-72). Washington: American Psychological Association.

Webb, W. B. (1995). The cost of sleep-related accidents: A reanalysis. Sleep, 18, 276-280.

Wilkinson, R. T. (1992). The measurement of sleepiness. In R. J. Broughton & R. D. Ogilvie (Eds.) Sleep, Arousal, and Performance (pp 254-265). Boston: Birkhauser.

Appendix A

SLEEP LABORATORY
Department of Psychology, Brock University
Unintentional Sleep Onset Study 1994
SUBJECT CONSENT FORM

I, _____, agree to spend two nights in the Brock University Sleep Laboratory (688-5550 X3795). I have been fully oriented regarding the procedure and understand the following points.

(1) I have been informed that I will be required to complete a screening questionnaire, a morningness/eveningness questionnaire and if accepted for the study a two week sleep log and a post experiment questionnaire.

(2) I understand that I will be required to come to the Sleep Lab for a brief training/orienting session prior to the experiment during which time I will be familiarized with the tasks and procedures in this study.

(3) I agree to refrain form using prescription and non- prescription drugs (excluding contraceptives), including alcohol and caffeine the day I will be in the sleep lab.

(4) I understand that I will be required to spend two non- consecutive nights in the sleep lab. I must awaken no later than 7:00 a.m. the day of the experiment and resist napping throughout the day. I must report to the sleep lab at approximately 8:30 p.m. and I will only be allowed minimal sleep until approximately 3:30 a.m. each night, but that I may sleep as long I wish after this time.

(5) I have been informed that electrodes will be placed on my head, by my eyes, behind my ears, and under my chin. I have been informed that data from these electrodes will be recorded on tape and/or paper and/or computer.

(6) I have been informed that I will be required to complete a series of tasks as follows.

(a) Approximately every 30 minutes I will have my oral temperature measured and my sleepiness measured using two subjective rating scales.

(b) Every hour I will be given a small drink of water and taken for a short walk (approximately 50-100 metres). I will then be have my reaction time measured using a computer task as well as my subjective and objective sleepiness. I will be asked to sit comfortably and alternately open and close my eyes each minute for six minutes. I will then be asked to lie down with my eyes closed in a darken room for a period of no more than 30 minutes. On some of these occasions I will be asked to try and fall asleep, on other occasions I will be asked to attempt to remain awake. Once I have fallen asleep I will be wakened during the experiment, but will be allowed to sleep as long as I wish once the experiment has finished each evening.

(7) I have been informed that two experimenters (one male and one female) will be in the sleep lab at all times during the experiment and that I may ask for assistance or information at any time.

(8) I have been informed that, based on prior research, there should be no danger to my health. However, I have been told that if I have any past medical history which suggests that complications could occur because of my participation in this study, the experimenter should be consulted prior to the beginning of the experiment.

(9) I have been informed that I will receive a $25 honorarium and course credit (if applicable) for my participation.

(10) I understand that I may withdraw from this study at any time without prejudice. I may also withdraw the use of any data collected regarding myself if I so choose in the future.

(11) I understand that all data collected will be regarded as confidential and identified only by code. I understand that any results reported concerning my data will not identify me as a participant.

(12) I understand that results of the experiment will be made available, but that the experiment is not of a clinical nature. I will therefore only receive basic, publicly available, information and advice concerning sleep patterns and practices. I understand that the researcher is not a medical doctor and I will not receive any information concerning my own data which requires any form of judgement regarding a medical condition.

I have read and understood the above statement, and I freely consent to participate in this research.

Name (printed): _____

Signature: _____

Date: _____

Address: _____

_____

Telephone: _____

I have explained the nature of this study to the participant and I believe that she understands it.

Signature _____ (Tim Murphy)

Investigators:

Tim Murphy (M.A. student)
Robert Ogilvie PhD. (Supervisor)

Appendix B

Circadian Rhythm Questionnaire

J. A. Horne and O. Ostberg

Instructions

1. Please read each question very carefully before answering.

2. Answer ALL questions.

3. Answer questions in numerical order.

4. Each question should be answered independently of the others. Do NOT go back and check your answers.

5. All questions have a selection of answers. For each question place a cross alongside ONE answer only. Some questions have a scale instead of a selection of answers. Place a cross at the appropriate point along the scale.

6. Please answer each question as honestly as possible. Both your answers and the results will be kept in strict confidence.

7. Please feel free to make any comments in the section provided below each question.

Please supply the information requested below.

Name: _____

Sex: Male Female

Age: _____ years

Please turn to next page . . .

1. Considering your own "feeling best" rhythm, at what time would you get up if you were free to plan your day?

| -+- | -+- | -+- | -+- | -+- | -+- | -+- |

a.m. 5 6 7 8 9 10 11 12

2. Considering your own "feeling best" rhythm, at what time would you go to bed if you were free to plan your evening?

| -+- | -+- | -+- | -+- | -+- | -+- | -+- |

p.m. 8 9 10 11 12 a.m. 1 2 3

3. If there is a specific time at which you have to get up in the morning, to what extent are you dependent on being woken up by an alarm clock?

- Not at all dependent. . . . . ☐
- Slightly dependent . . . . . ☐
- Fairly dependent . . . . . ☐
- Very dependent . . . . . ☐

4. Assuming adequate environmental conditions, how easy do you find getting up in the morning?

- Not at all easy. . . . . ☐
- Not very easy . . . . . ☐
- Fairly easy . . . . . ☐
- Very easy . . . . . ☐

5. How alert do you feel during the first half hour after having woken in the morning?

- Not at all alert . . . . . ☐
- Slightly alert . . . . . ☐
- Fairly alert . . . . . ☐
- Very alert . . . . . ☐

6. How is your appetite during the first half hour after having woken in the morning?

- Very poor . . . . . ☐
- Fairly poor . . . . . ☐
- Fairly good . . . . . ☐
- Very good . . . . . ☐

Please turn to next page . . .

7. During the first half hour after having woken in the morning, how tired do you feel?

- Very tired . . . . . ☐
- Fairly tired . . . . . ☐
- Fairly refreshed . . . . . ☐
- Very refreshed . . . . . ☐

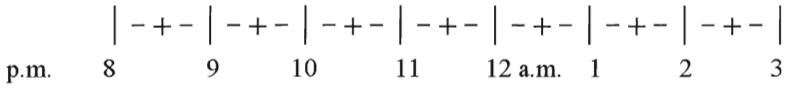
8. When you have no commitments the next day, at what time do you go to bed compared to your usual bedtime?

- Seldom or never later . . . . ☐
- Less than one hour later . . ☐
- 1-2 hours later . . . . . ☐
- More than 2 hours later . . ☐

9. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him/her is between 7:00 - 8:00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?

- Would be in good form . . . . . ☐
- Would be in reasonable form . . . . . ☐
- Would find it difficult . . . . . ☐
- Would find it very difficult . . . . . ☐

10. At what time in the evening do you feel tired and as a result in need of sleep?



11. You wish to be at peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day and considering only your own "feeling best" rhythm which ONE of the four testing times would you choose?

- 8:00 - 10:00 a.m. . . . . ☐
- 11:00 a.m. - 1:00 p.m. . . . ☐
- 3:00 - 5:00 p.m. . . . . ☐
- 7:00 - 9:00 p.m. . . . . ☐

Please turn to next page . . .

12. If you went to bed at 11:00 p.m. at what level of tiredness would you be?

- Not at all tired . . . . . ☐
- A little tired . . . . . ☐
- Fairly Tired . . . . . ☐
- Very Tired . . . . . ☐

13. For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following events are you most likely to experience?

- Will wake up at usual time and will NOT fall asleep . ☐
- Will wake up at usual time and will doze thereafter . . ☐
- Will wake up at usual time but will fall asleep again . . ☐
- Will NOT wake up until later than usual . . . . . ☐

14. One night you have to remain awake between 4:00 - 6:00 a.m. in order to carry out a night watch. You have no commitments the next day. Which ONE of the following alternatives will suit you best?

- Would NOT go to bed until watch was over . . . . . ☐
- Would take a nap before and sleep after . . . . . ☐
- Would get a good sleep before and a nap after . . . . ☐
- Would take ALL sleep before watch . . . . . ☐

15. You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own "feeling best" rhythm which ONE of the following times would you choose?

- 8:00 - 10:00 a.m. . . . . ☐
- 11:00 a.m. - 1:00 p.m. . . . ☐
- 3:00 - 5:00 p.m. . . . . ☐
- 7:00 - 9:00 p.m. . . . . ☐

Please turn to next page . . .

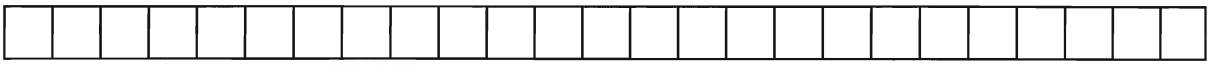
16. You have decided to engage in hard physical exercise. A friend suggests that you do this one hour twice a week and the best time for him/her is between 10:00 - 11:00 p.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?

- Would be in good form . . . . . ☐
- Would be in reasonable form . . . . . ☐
- Would find it difficult . . . . . ☐
- Would find it very difficult . . . . . ☐

17. Suppose that you can choose your own work hours. Assume that you worked a FIVE hour day (including breaks) and that your job was interesting and paid by results. Which FIVE consecutive hours would you select?

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Midnight Noon Midnight

18. At what time of day do you think that you reach your "feeling best" peak?



12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
Midnight Noon Midnight

19. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

- Definitely a "morning" type . . . . . ☐
- Rather more a "morning" than an "evening" type . . . ☐
- Rather more an "evening" than a "morning" type . . . . ☐
- Definitely and "evening" type . . . . . ☐

Circadian Rhythm Questionnaire Scoring Sheet

J. A. Horne and O. Ostberg

Scoring Instructions

1. Each question receives only one score.

2. For questions which have a choice of four answers (#'s 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 19) the score is shown on the right beside each choice.

3. For questions which require one mark on a continuous scale (#'s 1, 2, 10) the ranges which indicate the score to be assigned are shown below the scale.

4. For questions 17 and 18 assign the score which falls at the midpoint of the five hour period they have indicated.

5. Mark the score beside each question on the **original** questionnaire. **DO NOT** mark on this score sheet!

6. Add up all scores.

7. Use the table shown below to determine the category.

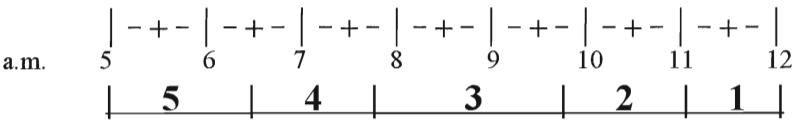
8. Mark the score and category on the cover of the **original** questionnaire.

Definite Morning	70-86
Moderate Morning	59-69
Neither	42-58
Moderate evening	31-41
Definite evening	16-30

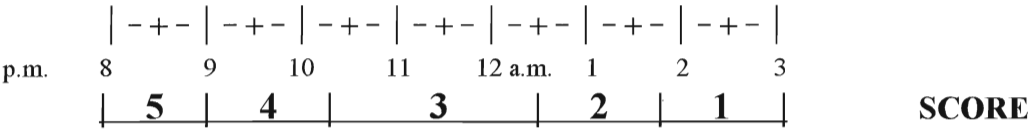
Please turn to next page . . .

Circadian Rhythm Questionnaire Scoring Sheet

1. Considering your own "feeling best" rhythm, at what time would you get up if you were free to plan your day?



2. Considering your own "feeling best" rhythm, at what time would you go to bed if you were free to plan your evening?



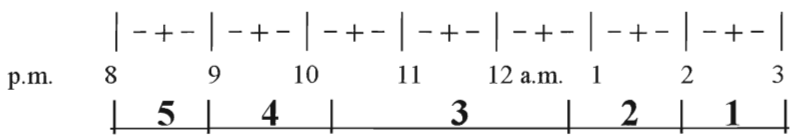
3.	If there is a specific time at which you have to get up in the morning, to what extent are you dependent on being woken up by an alarm clock?	Not at all dependent. . . . . ☐ Slightly dependent . . . . . ☐ Fairly dependent . . . . . ☐ Very dependent . . . . . ☐	**4** **3** **2** **1**
4.	Assuming adequate environmental conditions, how easy do you find getting up in the morning?	Not at all easy. . . . . ☐ Not very easy . . . . . ☐ Fairly easy . . . . . ☐ Very easy . . . . . ☐	**1** **2** **3** **4**
5.	How alert do you feel during the first half hour after having woken in the morning?	Not at all alert . . . . . ☐ Slightly alert . . . . . ☐ Fairly alert . . . . . ☐ Very alert . . . . . ☐	**1** **2** **3** **4**
6.	How is your appetite during the first half hour after having woken in the morning?	Very poor . . . . . ☐ Fairly poor . . . . . ☐ Fairly good . . . . . ☐ Very good . . . . . ☐	**1** **2** **3** **4**

Please turn to next page . . .

Circadian Rhythm Questionnaire Scoring Sheet

			SCORE
7.	During the first half hour after having woken in the morning, how tired do you feel?	Very tired . . . . . ☐	1
		Fairly tired . . . . . ☐	2
		Fairly refreshed . . . . . ☐	3
		Very refreshed . . . . . ☐	4
8.	When you have no commitments the next day, at what time do you go to bed compared to your usual bedtime?	Seldom or never later . . . . ☐	4
		Less than one hour later . . ☐	3
		1-2 hours later . . . . . ☐	2
		More than 2 hours later . . ☐	1
9.	You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him/her is between 7:00 - 8:00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?	Would be in good form . . . . . ☐	4
		Would be in reasonable form . . . . . ☐	3
		Would find it difficult . . . . . ☐	2
		Would find it very difficult . . . . . ☐	1

10. At what time in the evening do you feel tired and as a result in need of sleep?



			SCORE
11.	You wish to be at peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day and considering only your own "feeling best" rhythm which ONE of the four testing times would you choose?	8:00 - 10:00 a.m. . . . . ☐	6
		11:00 a.m. - 1:00 p.m. . . . ☐	4
		3:00 - 5:00 p.m. . . . . ☐	2
		7:00 - 9:00 p.m. . . . . ☐	0

Please turn to next page . . .

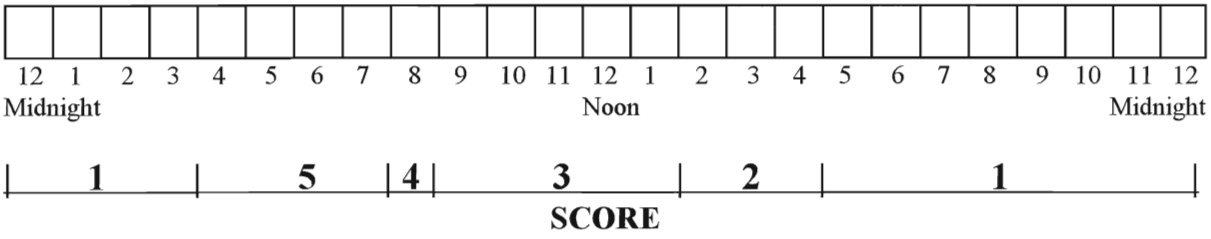
Circadian Rhythm Questionnaire Scoring Sheet

			SCORE
12.	If you went to bed at 11:00 p.m. at what level of tiredness would you be?	Not at all tired . . . . . ☐	0
		A little tired . . . . . ☐	2
		Fairly Tired . . . . . ☐	3
		Very Tired . . . . . ☐	5
13.	For some reason you have gone to bed several hours later than usual, but there is no need to get up at any particular time the next morning. Which ONE of the following events are you most likely to experience?	Will wake up at usual time and will NOT fall asleep . ☐	4
		Will wake up at usual time and will doze thereafter . . ☐	3
		Will wake up at usual time but will fall asleep again . . ☐	2
		Will NOT wake up until later than usual . . . . . ☐	1
14.	One night you have to remain awake between 4:00 - 6:00 a.m. in order to carry out a night watch. You have no commitments the next day. Which ONE of the following alternatives will suit you best?	Would NOT go to bed until watch was over . . . . . ☐	1
		Would take a nap before and sleep after . . . . . ☐	2
		Would get a good sleep before and a nap after . . . . ☐	3
		Would take ALL sleep before watch . . . . . ☐	4
15.	You have to do two hours of hard physical work. You are entirely free to plan your day and considering only your own "feeling best" rhythm which ONE of the following times would you choose?	8:00 - 10:00 a.m. . . . . ☐	4
		11:00 a.m. - 1:00 p.m. . . . ☐	3
		3:00 - 5:00 p.m. . . . . ☐	2
		7:00 - 9:00 p.m. . . . . ☐	1

Please turn to next page . . .

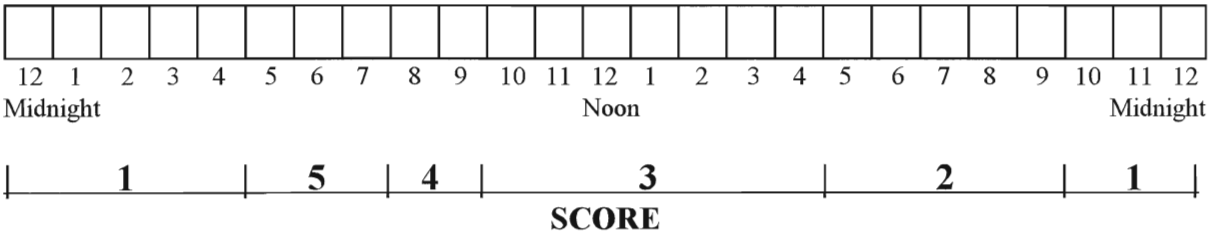
			SCORE
16.	You have decided to engage in hard physical exercise. A friend suggests that you do this one hour twice a week and the best time for him/her is between 10:00 - 11:00 p.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?	Would be in good form . . . . . ☐	1
		Would be in reasonable form . . . . . ☐	2
		Would find it difficult . . . . . ☐	3
		Would find it very difficult . . . . . ☐	4

17. Suppose that you can choose your own work hours. Assume that you worked a FIVE hour day (including breaks) and that your job was interesting and paid by results. Which FIVE consecutive hours would you select?



SCORE

18. At what time of day do you think that you reach your "feeling best" peak?



SCORE

			SCORE
19.	One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?	Definitely a "morning" type . . . . . ☐	6
		Rather more a "morning" than an "evening" type . . . ☐	4
		Rather more an "evening" than a "morning" type . . . . ☐	2
		Definitely and "evening" type . . . . . ☐	0

Appendix C

SLEEP LABORATORY
Department of Psychology, Brock University
Unintentional Sleep Onset Study 1994

SUBJECT SCREENING QUESTIONNAIRE

Name: _____ Age: _____

Telephone: _____ Sex: _____

Please circle the best response for each question or fill in the blank if required.

1. **How many hours do you routinely sleep each night?**

less than 5 5 6 7 8 9 10 more than 10

Does this vary much? yes no

How long does it typically take you to fall asleep?

Less than 5 min. 5 to 10 min. 10 to 20 min over 20 min.

2. **Do you smoke?** Yes No **Have you ever smoked?** Yes No

How long has it been since you quit? _____

3. **How many cups of coffee or tea do you drink in an average day?**_____

4. **How many sodas/pops do you drink in an average day?** _____

5. **How many alcoholic drinks do you consume in a week?** _____

6. **Are you taking any prescribed or non-prescribed drugs (including recreational drugs) OTHER THAN birth control pills?** Yes No

7. **Have you ever had a head injury?** Yes No

8. **Do you have any neurological disorders (seizures, etc)?** Yes No

9. **Have you ever been on medication for a long period of time?** Yes No

Appendix D

Stanford Sleepiness Scale

Please circle the number which best describes how you feel based on the statements given below.

1 Feeling active and vital; alert; wide awake

2 Functioning at a high level, but not at peak; able to concentrate

3 Relaxed; awake; not at full alertness; responsive

4 A little foggy; not at peak let down

5 Fogginess; beginning to lose interest in remaining awake; slowed down

6 Sleepiness; prefer to be lying down; fighting sleep; woozy

7 Almost in reverie; sleep onset soon; lost struggle to remain awake

Appendix E

Visual Analogue Sleepiness Scale

Please indicate how you feel by placing a mark on this line.

Very Sleepy _____ Very Alert

Appendix F

Sleep Log Instructions

In this envelope you will find 8 copies of your daily sleep log. Each sheet is to be used for ONE day only. As you finish with each sheet put it back in the envelope and do not refer back to it. You are to begin filling these out on Monday October 31, seven days prior to the first day you come into the sleep lab. Use one sheet each day INCLUDING the day you come into the lab. Please bring your first 8 sheets with you to the lab. Repeat this process beginning seven days before your second night in the lab. Bring the second set of sheets with you when you return to the lab. Since you are scheduled for two nights which are exactly one week apart, simply continue the sleep log for one more week.

I realize that the sleep log can be inconvenient and you may not always be able to fill it out "on time". If you miss a section do not worry, simply fill it out as best you can from memory but indicate when it was actually done. If you have any questions you can reach me (or leave a message) at school during the day (and often at night) 688-5550 extension 3795 or 4419, at home 905-382-2952, or I can usually be found in B309 or the sleep lab (B416).

The night you come into the lab, could you please plan on arriving between 8:00 p.m. and 8:30. Bring an overnight bag with toothbrush etc, and something comfortable to sleep in. It will take approximately one hour to apply the electrodes so you may wish to bring some light reading. In the morning it will take 15 minutes or so to remove the electrodes so if you have an appointment please take this time into account. There is a full washroom with a shower in the sleep lab at your disposal. If you wish to sleep in longer, you can bring a change of clothing and go to your classes directly from the sleep lab. As always you can call me for further information if you have any questions.

Sleep Log

This page is to be used for one day only. date _____

PLEASE ANSWER THESE QUESTIONS WHEN YOU GET UP IN THE MORNING

What time did you go to bed last night? _____hrs_____mins

How long did it take you to get to sleep? _____hrs_____mins

How often did you wake up during the night? _____

During these awakenings how long were you up? _____hrs_____mins (total)

What time did you get up this morning? _____hrs_____mins

Was last nights sleep typical for you? Yes No

If "No", what was different? _____

why was it different? (stress, room temperature, noise, etc)

_____

Please indicate how well you slept by circling a number.

Best Possible Sleep 1 2 3 4 5 6 7 Worst Possible Sleep

Please indicate how you feel by placing a mark on this line.

Very Sleepy _____ Very Alert

Please circle the number which best describes how you feel based on the statements given below.

1 Feeling active and vital; alert; wide awake
2 Functioning at a high level, but not at peak; able to concentrate
3 Relaxed; awake; not at full alertness; responsive
4 A little foggy; not at peak let down
5 Fogginess; beginning to lose interest in remaining awake; slowed down
6 Sleepiness; prefer to be lying down; fighting sleep; woozy
7 Almost in reverie; sleep onset soon; lost struggle to remain awake

PLEASE ANSWER THESE QUESTIONS IN THE LATE AFTERNOON

What time is it? _____hrs_____mins

Please indicate how you feel by placing a mark on this line.

Very Sleepy _____ Very Alert

Please circle the number which best describes how you feel based on the statements given below.

1 Feeling active and vital; alert; wide awake
2 Functioning at a high level, but not at peak; able to concentrate
3 Relaxed; awake; not at full alertness; responsive
4 A little foggy; not at peak let down
5 Fogginess; beginning to lose interest in remaining awake; slowed down
6 Sleepiness; prefer to be lying down; fighting sleep; woozy
7 Almost in reverie; sleep onset soon; lost struggle to remain awake

PLEASE ANSWER THESE QUESTIONS JUST BEFORE YOU GO TO BED

Did you take any Naps today? Yes No

How many? _____ What times? from _____ to _____

Did you exercise today? Yes No What time? _____ How long? _____

Was this day typical? Yes No Explain _____

How much of each of the following did you have today?

cups of coffee? _____ approximate times _____

cups of tea? _____ approximate times _____

glasses of cola?_____ approximate times _____

chocolate? _____ approximate times _____

beer, wine, alcohol? _____ approximate times _____

Please indicate how your day was by circling a number.

Calm	1	2	3	4	5	6	7	Busy
Pleasant	1	2	3	4	5	6	7	Unpleasant
NOT Stressful	1	2	3	4	5	6	7	VERY Stressful

Please indicate how you feel by circling a number.

Depressed	1	2	3	4	5	6	7	Happy
Anxious	1	2	3	4	5	6	7	Relaxed

Please describe any events (good or bad) that occurred today which you feel may affect your mood or sleep patterns. (use the back of the page if necessary)

Please indicate how you feel by placing a mark on this line.

Very Sleepy _____ Very Alert

Please circle the number which best describes how you feel based on the statements given below.

1 Feeling active and vital; alert; wide awake
2 Functioning at a high level, but not at peak; able to concentrate
3 Relaxed; awake; not at full alertness; responsive
4 A little foggy; not at peak let down
5 Fogginess; beginning to lose interest in remaining awake; slowed down
6 Sleepiness; prefer to be lying down; fighting sleep; woozy
7 Almost in reverie; sleep onset soon; lost struggle to remain awake

What time are you going to bed tonight? _____hrs_____mins

ONCE YOU HAVE COMPLETED THIS PAGE, PLEASE PUT IN THE ENVELOPE PROVIDED AND DO NOT REFER BACK TO IT.

Appendix G

PRE SLEEP QUESTIONNAIRE

What time did you go to bed last night? _____hrs_____mins

How long did it take you to get to sleep? _____hrs_____mins

How often did you wake up during the night? _____

During these awakenings how long were you up? _____hrs_____mins (total)

What time did you get up this morning? _____hrs_____mins

Was last nights sleep typical for you? Yes No

If "No", what was different? _____

why was it different? (stress, room temperature, noise, etc)

_____

Please indicate how well you slept by circling a number.

Best Possible Sleep 1 2 3 4 5 6 7 Worst Possible Sleep

Did you take any Naps today? Yes No

How many? _____ What times? from _____ to _____

Did you exercise today? Yes No What time? _____ How long? _____

Was this day typical? Yes No Explain _____

How much of each of the following did you have today?

cups of coffee? _____ approximate times _____

cups of tea? _____ approximate times _____

glasses of cola? _____ approximate times _____

chocolate? _____ approximate times _____

beer, wine, alcohol? _____ approximate times _____

Please indicate how your day was by circling a number.

Calm	1	2	3	4	5	6	7	Busy
Pleasant	1	2	3	4	5	6	7	Unpleasant
NOT Stressful	1	2	3	4	5	6	7	VERY Stressful

Please indicate how you feel by circling a number.

Depressed	1	2	3	4	5	6	7	Happy
Anxious	1	2	3	4	5	6	7	Relaxed

Please describe any events (good or bad) that occurred today which you feel may affect your mood or sleep patterns.

_____

_____

Please indicate how you feel by placing a mark on this line.

Very Sleepy _____ Very Alert

Please circle the number which best describes how you feel based on the statements given below.

1 Feeling active and vital; alert; wide awake

2 Functioning at a high level, but not at peak; able to concentrate

3 Relaxed; awake; not at full alertness; responsive

4 A little foggy; not at peak let down

5 Fogginess; beginning to lose interest in remaining awake; slowed down

6 Sleepiness; prefer to be lying down; fighting sleep; woozy

7 Almost in reverie; sleep onset soon; lost struggle to remain awake

Appendix H

Instructions for the Alpha Attenuation Test

These are the instructions which will be read to the subjects for the tests indicated are in **bold**, other aspects of each test are in standard font. This test will be conducted with the subject in the sleep lab bedroom, the electrodes connected to the EEG machine and recordings being taken.

The subject will be seated on the side of her bed.

Please relax, keep your eyes open and look at the black square on the wall, try not to move your eyes.

After one minute the subject is told.

Continue to relax, close your eyes and look straight ahead, try not to move your eyes.

After one minute the subject will be told the first instructions again (eyes open) and this process is repeated three times for a total of 6 minutes.

Appendix I

Post Experiment Questionnaire

First let me assure you that your responses on this questionnaire will in no way affect your honorarium and/or participation credit. This questionnaire will NOT be opened and evaluated until all your data have been collected.

Since this is a new area of research, I am relying on your honest responses to help me refine and improve the methods I am developing. Also, in order for me to do a proper analysis it is important that I have an accurate measurement of your effort. If your effort was at any time less than optimal, do not be embarrassed or concerned about not trying your hardest, no one can do their best all the time. However, it is important for me to know how hard you tried. So please do you best to be candid.

If you feel that any of the questions do not allow you enough freedom to adequately respond, feel free to write comments in the margins or on the back of the page if necessary.

These first few questions concern the "GO TO SLEEP" test.

1. During the times when I asked you to try and go TO SLEEP, the instructions were as follows
   "For this test you are to close your eyes, lay still, relax and allow yourself to fall asleep. Any questions? Good Night".
   How well do you think you followed the instructions?

not very well at all 1 2 3 4 5 6 7 very well

2. When you were asked to fall asleep, how hard did you consciously try to go to sleep?

very little effort 1 2 3 4 5 6 7 very much effort

Did your level of effort to go to sleep vary much? Yes No
If YES, how did it vary (e.g. had to try harder later in the night, tried hard at first but not as hard later, tried the first night but not as much the second night, etc)

_____

_____

3. How easy was it for you to fall asleep when you were asked to fall asleep?

very easy 1 2 3 4 5 6 7 very hard

4. Did you develop any strategies to help you fall asleep more quickly? Yes No

If you answered Yes, please answer the following 4 questions.
What types of strategies did you use?_____
When did you begin to use strategies?_____
Did you continue to use them?_____
How often did you use these strategies?

very often 1 2 3 4 5 6 7 very seldom

The next few questions concern the "STAY AWAKE" test.

5. During the times when I asked you to try and STAY AWAKE, the instructions were as follows,

"For this test you are to close your eyes, lay still and relax, but do your best to remain awake. These instructions may seem very contradictory but I am not trying to mislead you in any way. For the purposes of my study it is important you follow them as closely as you can. It is important that you close your eyes, but remain awake as long as possible. It is also important that you do not unnecessarily move, or engage in any mental activity such as singing to yourself. Movements, even the tiny ones which occur when you sing to yourself, or tap your feet will be picked up by the EEG machine and make your data harder to interpret. Of course if you are uncomfortable feel free to reposition yourself as you would normally. Any Questions? Remember, close your eyes but try and stay awake."

How well do you think you followed the instructions to stay awake?

not very well at all 1 2 3 4 5 6 7 very well

6. When you were asked to stay awake, how hard did you consciously try to go to stay awake?

very little effort 1 2 3 4 5 6 7 very much effort

Did your level of effort to stay awake vary much? Yes No
If YES, how did it vary (e.g. had to try harder later in the night, tried hard at first but gave up later, tried the first night but not the second etc)

_____

_____

7. How easy was it for you to stay awake when you were asked to do this?

very easy 1 2 3 4 5 6 7 very hard

8. Did you develop any strategies to help you stay awake?
Yes No
If you answered Yes, please answer the following 4 questions.
What types of strategies did you use?_____
When did you begin to use strategies?_____
Did you continue to use them?_____
How often did you use these strategies?

very often 1 2 3 4 5 6 7 very seldom

These next few questions involve both tests.

9. Which statement best describes your use of strategies.
a. I did not use strategies for either test.
b. I used strategies equally often in both tests.
c. I used strategies more often in the stay awake test.
d. I used strategies more often in the go to sleep test.

10. I want to compare the experiences people had in the two versions of the nap tests in my experiment. Please answer the following questions based on your experiences. Feel free to make additional comments beside any of the questions.

Were your thoughts (what was going through your mind) the same during the two tests? Yes No
If Yes, what types of things did you think about?_____

If No, please answer the following questions.

A Were you more likely to have "dream like" thoughts in one test or the other. Yes No
If Yes, Which test? _____

B Were your thoughts more structured in one test more that the other? Yes No
If Yes, which test_____

C Were your thoughts coherent during both tests? Yes No
If No, what were the differences?_____

_____

D Were your thoughts continuous (no lapses in attention) during both tests? Yes No
If No, how were they different?_____

_____

In general, what types of thoughts did you have in the "GO TO SLEEP" test?

_____

_____

In general, what types of thoughts did you have in the "STAY AWAKE" test?

_____

_____

Anything else? Please feel free to list or discuss any other experiences you had during the experiment or other comments you have concerning this experiment on the back of this page. Your observations are appreciated.

One last item.

11. How convinced were you that I had explained the TRUE purpose of the experiment? (circle one)

not at all convinced	1	2	3	4	5	6	7 completely convinced

If you were not completely convinced, what did you think I was concealing, or what did you think was the true purpose of the experiment?

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THANK YOU for your honest answers and for participating in my experiment. Research could not be conducted if it were not for volunteers like yourself. If you wish to find out the results of this experiment, I should have some preliminary analysis done and ready for you by January. I can be reached at 688-5550 x3795, or you can often find me in B309 or the sleep lab (B416). Thanks again, I hope you enjoyed your experience. If you are interested in other sleep research let me know, there will be other experiments in the future and we are always on the lookout for volunteers.
Please put this in the envelope provided and return it to the Psychology office.